IMPACT OF CLOUD SERVICES ON STUDENTS' ATTITUDE TOWARDS MATHEMATICS EDUCATION IN PUBLIC UNIVERSITIES IN BENUE STATE, NIGERIA

By

ABAH, Joshua Abah

JANUARY, 2017.

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By

ABAH, Joshua Abah

(13/6624/M.Ed)

B.Sc.(Ed) Statistics and Computer Science

(University of Agriculture, Makurdi)

A Thesis submitted to the Department of Science Education, College of Agricultural and Science Education, University of Agriculture, Makurdi, in partial fulfilment of the requirement for the award of Master of Education in Mathematics Education.

JANUARY, 2017.

DECLARATION

I declare that this thesis is an original work produced by me and has not been previously submitted to any University or similar Institution for the award of any degree.

Name of Candidate: Abah, Joshua Abah

Signature of Candidate: ………………………………….

Date: ……………………………………………………...

CERTIFICATION

We the undersigned hereby certify that this thesis has been read, examined and accepted for ABAH, JOSHUA ABAH (13/6624/M.Ed), to be presented in the Department of Science Education as fulfilling part of the requirements for the award of Master of Education (M.Ed) in Mathematics Education.

Topic: ***Impact of Cloud Services on Students' Attitude towards Mathematics Education in Public Universities in Benue State, Nigeria.***

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Prof. C. O. Iji Date

Supervisor

……………………………… …………………………….

Dr. J. W. Anyor Date

Co-Supervisor

……………………………… ……………………………..

Dr. O. K. Okwara Date

H.O.D., Science Education

……………………………… ……………………………

Prof. E. U. Amuta Date

Dean, Post Graduate School

DEDICATION

This work is dedicated to Almighty God, who alone charted the course of my career, my wife Christy and my son Prime.

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ABSTRACT

This study was designed to investigate the impact of cloud services on students' attitude towards mathematics education in public universities in Benue State, Nigeria. Ex-post facto research design was adopted for the study. The instrument for the study is the researcher-developed Cloud Service Impact Questionnaire – CSIQ (Cronbach Alpha Coefficient = 0.92). The CSIQ was administered to a sample of 328 mathematics education students drawn from the two public universities having operational cloud service delivery system in Benue State. Six research questions guided the study and two hypotheses were tested. Mean and standard deviation were used to answer research questions while t-test was used in testing the hypotheses at 0.05 level of significance. In-depth analysis of data obtained in the study revealed that there is a positive high level of impact of cloud services on the mathematics confidence (cluster mean attitude score = 2.85), affective engagement (cluster mean attitude score = 2.87) and behavioural engagement (cluster mean attitude score = 2.92) of mathematics education students in public universities in Benue State. The results also indicated a high frequency of usage of cloud services, with smartphones (49 %), tablets (24 %) and laptops (16 %) being the set of computer devices readily available among mathematics education students in public universities in Benue State. The t-test analysis of mean attitude scores established a statistically significant difference between the public universities. The mean difference in attitude scores between male and female mathematics education students was also found to be statistically significant. The outcome of this study has shown that adoption of cloud services for augmenting learning results in strong positive mentality and confidence among mathematics education students, leading to students feeling good, thinking hard and actively participating in their own mathematics learning. Based on the findings of the study, it was recommended that students of mathematics education should seek deeper and more enriched learning experience by continuously leveraging on available cloud services, benefiting from several online mathematical communities and developing themselves in life-sustaining skills. Mathematics educators should incorporate emergent technologies like the educational cloud in their instructional design to flexibly support the teaching and learning process and improve students. More instructional aids can be cued from the World Wide Web (WWW) via educational institution-hosted cloud services for all round pedagogical development.

1.0 INTRODUCTION

1.1 Background of the Study

Education is a conscious effort of the society to inculcate her existing body of knowledge, values, norms, science and technology into the young generation for the purpose of active participation in the society. To achieve this purpose, the society engages the services of educational institutions where children are taken through well-planned structures. From the standpoint of society, one of the most urgent aims of education is to facilitate social and economic development (Cassady, 2014). As such, education is expected to expose learners to the scientific and analytical thinking skills they need to understand, build and innovate new technologies.

Education in the 21st century is more than mere transfer of knowledge. The role of education is not one of following and reacting to trends (Raja, 2002). Education has come to be in the lead and play a major role in societal development of the future. With the integration of available information and communications technology (ICT) components, education has risen to become the fulcrum on which the competitiveness of nations in the global community rests (Iji, Abah & Uka, 2013). ICT networks are now making it possible for developing countries to participate in the world economy in ways that simply were not possible in the past (Baez, Kechiche & Boguszewska, 2010). Emerging economies such as Nigeria are becoming the destination for new investment opportunities via the provision of enabling environment that encourages the development of technological infrastructure.

Mathematics education is an umbrella term that encompasses all aspects of learning and teaching of mathematics in schools and in other settings. Mathematics itself is an aid to representing and attempting to resolve problem situations in all disciplines. According to Odili (2012), it is a powerful means of communication, an intellectual endeavour and a mode of thinking. Mathematics is a discipline through which students can develop their ability to

appreciate the beauty of nature, think logically and make sound judgement. Mathematics education is considered as an intersection of mathematics pedagogy with the nature of mathematics as a discipline (Osafehinti, 2015). With focus on teacher education, mathematics education considers the design, implementation and effects of curriculum and instructional interventions; and contemporary developments in learning theories and technologies.

Technology, broadly understood, has been transforming human life in one way or another for thousands of years (Lokesh, 2013). But in the computer age, the pace of technological change is very rapid, altering schooling, work and social lives in ways that have significant consequences for young people (Craig, 2009). In rethinking education to cope with these changes at the threshold of the twenty-first century, innovation and research are indispensable tools. Failure to innovate, by and large, means repeating yesterday's educational programmes and strategies tomorrow (Raja, 2002). The society which education is meant to sustain is becoming transformed by trend such as automation, globalization, workplace culture and personal responsibility.

Within the demands of the time, both the education system and the educational process must be amenable. This calls for a fundamental qualitative transformation of education in terms of its content, methods and outcomes. Education should seek to inculcate skills that are aimed at accelerating technological change, rapidly accumulating knowledge, increasing global competition and rising workforce capabilities (Partnership for 21st Century Skills, 2002). Schools must equip students who will ultimately spend their adult lives in a multitasking, multifaceted, technology-driven, diverse and vibrant world. The reality on ground has made it imperative for the education system to be more strategic, aggressive and effective in preparing students to succeed and prosper. Educational institutions must rethink what, but even more importantly, how and where we learn (Innovation Unit, 2014).

Although it is clear that technology is not the solution to present day education (Lokesh, 2013), utilizing emerging technologies to provide expanded learning opportunities is critical to the success of future generations. The level of penetration of ICT among students signals more than a change in pedagogy; it suggests a change in the very meaning and nature of mathematics education itself (Italiano, 2014). Schools all over the world are becoming an integral part of the broadband and technological transformation, harnessing the potentials of technology to drive and empower more personalized mathematics learning.

One of the specific ways technology is enhancing present day mathematics teaching and learning is through the utilization of the cloud. The cloud is a set of hardware, networks, storage, services, and interfaces that enable the delivery of computing as a service (Hurwitz, Bloor, Kaufman & Halper, 2010). Cloud services include the delivery of software, infrastructure and storage over the internet, reducing cost and providing flexibility and mobility (Kovachev, Cao & Klamma, 2011). These services are delivered via the internet from high-specification data centres in locations remote from the end user.

Broadly, the cloud can be seen as an on-demand access to computer services, applications, network and data anywhere (Powell, 2009). In an educational institution, the cloud provides students with standard internet access that promotes the use of heterogeneous thin or thick client platforms (for example, mobile phones, laptops, and tablets). Students make use of several self-services by connecting to wireless access points spread across their school. This has become a modern tool, a way of fact-based learning which allows students to do a lot of research using the web and various tools (Lokesh, 2013). In the process, students' critical and literacy skills are enhanced.

The educational cloud involves all the learning students carry out on mobile phones, smartphones, tablets, palmtops, laptops and PCs while connected to Wi-Fi. It may include download of materials for assignments and research, studying online and other individualized

learning done via connectivity to the wireless cloud within the campus or elsewhere. The cloud services of public universities provide mathematics education students access to infrastructure and content, increased openness to new technologies, and general support for teaching and learning. With such support readily available, students' perspectives of mathematics, which have been usually attested to be skeptical, may be influenced.

Active utilization of cloud services provided by educational institutions has grown in importance as a result of a new genre of students with learning needs vastly different from their predecessors (Thomas, 2011). Present day students require increase network access to sustain their culture of learning, leisure and social interaction. The computing power provided by the cloud avails the opportunity to extend students' mathematics learning beyond the walls of the classroom, thereby offering the learner greater participation and control of the learning process.

Much flexibility, as provided by the availability of cloud services in institutions of higher learning, especially universities, is needed particularly in the teaching and learning of mathematics. Mathematics is core subject in the education of children. Its usefulness, power and beauty have been recognized to be fundamental to human development (Iji *et al.*, 2013). In modern society driven on the machinery of science and technology, mathematics stands tall as the queen of innovation and the language of nature (Antonio, 2008).

According to the United Nations Education, Scientific and Cultural Organization - UNESCO (2012), mathematics education that is relevant and of quality can develop critical and creative thinking, help learners to understand and participate in public policy discussions, encourage behavioural changes that can put the world on a more sustainable path and stimulate socio-economic development. Mathematics education creates a culture that values continuous learning, problem solving, reflection, and sharing of knowledge among staff, parents, and students (New Jersey Mathematics Curriculum Framework, 2014). In the present

world of constant flux, those who understand and do mathematics will have significantly enhanced opportunities and options for shaping their future (National Council of Teachers of Mathematics -NCTM, 2009).

Mathematics is an aid in representing and attempting to resolve problem situations in all disciplines. It is an interdisciplinary tool and language (Moursund, 2014). Mathematics education concerns the activity or practice of teaching mathematics (Ernest, 2014). According to O'Brien (2002) mathematics education is a good school of thinking. Doing mathematics entails building the right attitude for problems, ranging from simple to more complicated ones. One of the aims of mathematics education is to develop in society the general attitude of customization of mathematical principles to satisfy human needs (Dudley, 2010).

Students' attitude toward mathematics is seen as the pattern of beliefs and emotional dispositions associated with mathematics (Zan & Di-Martino, 2007). It is the positive or negative degree of affection towards the subject mathematics. Whitin (2007) maintains that what students believe about mathematics influences what they are willing to say publicly, what questions they are likely to pose, what risks they are willing to take, and what connections they make to their lives outside the classroom. Attitude entails confidence and engagement. How students feel about mathematics is an outcome that is heavily dependent on the local culture and context, age and stage (Pierce, Stacey & Barkatsas, 2007).

Attitudes towards mathematics have been described as inclinations and predispositions that guide an individual's behaviour in mathematics (Rubinstein in Mohamed & Waheed, 2011). Learners form views about their own competence and learning characteristics which have considerable impact on the way they set goals, the strategies they use and their achievement (Zimmerman, 1995). Chamberlin (2010) posited that attitude

towards mathematics comprises components such as mathematics confidence, affective engagement, and behavioural engagement.

Mathematics confidence is a measure of students' personal belief in their own ability to handle learning situations in mathematics effectively, overcoming difficulties (Mohamed & Waheed, 2011; Santos & Barmby, 2010). Mathematics confidence affects students' willingness to take on challenging tasks and to make an effort and persist in tackling them.

Generally, engagement in mathematics refers to students' psychological investment in and effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote (Santos & Barnby, 2010). In the mathematics classroom, engaged students are actively participating, genuinely valuing, and reflectively involved in deep understanding of mathematical concepts and applications, and expertise (Attard, 2012). Affective engagement is students' own interest and enjoyment of mathematics as well as reactions to external incentives (Organization for Economic Co-operation and Development - OECD, 2004). Subject motivation is often regarded as the driving force behind learning. Interest in and enjoyment of mathematics is a relatively stable orientation that affects the intensity and continuity of engagement in learning situations, the selection of strategies and the depth of understanding.

Students are active participants in the learning process, constructing meaning in ways shaped by their own prior knowledge and new experiences. Behavioural engagement in mathematics refers to students' disposition to manage their own learning by choosing appropriate learning goals, using their existing knowledge and skills in mathematics to direct their learning, and selecting learning strategies appropriate to the task in hand (OECD, 2004). To do this they must be able to establish goals, persevere, monitor their progress, adjust their learning strategies as necessary, and overcome difficulties in learning. According to Abd-Wahid and Shahrill (2014), behavioural engagement is expressed in dimensions such as

attentiveness, diligence, time spent on task and non-assigned time spent on task. Behavioural engagement draws on the idea of participation and includes involvement in academic, social, or extracurricular activities and is considered crucial of achieving positive academic outcomes and preventing dropping out (Fredricks & McColskey, 2012).

Students' attitudes towards mathematics education determine whether they respond favourably or unfavourably to any discriminable aspect of mathematics. Other researcher as Schau (2003) relates that these attitudes are displayed through four important components: affect (students' feelings concerning mathematics education), cognitive competence (students' attitudes about their intellectual knowledge and skills when applied to mathematics), value (students' attitude about the usefulness, relevance, and worth of mathematics education in personal and professional life), and difficulty (students attitude about the difficulty of mathematics as a subject). Historically, mathematics teaching does not always allow students to develop positive attitudes towards the discipline (Lafortune, Daniel, Fallascio, & Schleider, 2000). This stems from accumulated myths about the difficulty of mathematics as a school subject and the deployment of instructional strategies that seriously stunt the growth of students' mathematical reasoning and problem solving skills (Larson, 2002).

The influence of faulty foundations in mathematics becomes more evident as students move further up the educational ladder. Attitudinal issues in mathematics not remedied from the lower levels of education tend to impede students development in mathematics later in life, even when they are enrolled in mathematics-related fields of study (Tekerek, Yeniterzi & Ercan, 2011). Mathematics educators are becoming increasingly concerned about the large number of unenthusiastic and poor attitudes that have been observed in many students (Goodykoontz, 2009).

Kaino (2009) observes that university students' background shows that most students were mainly encouraged to study mathematics by mathematics teachers at secondary and high school levels. This motivation wanes gradually as students confront diverse methodologies and approaches of instruction in the university. Quite often, even students of mathematics education find it difficult to maintain a proper balance between challenge and frustration (Goodykoontz, 2009). The outcome of the interplay of forces often at work in the undergraduate is the display of consistent poor attitude towards mathematics.

The myths deepen further when considered in relation to gender. Steele and Ambady (2006) observed that the continuous under-representation of women in gender-stereotyped fields such as mathematics and science has hampered the development of positive attitudes towards mathematics in women. Existing cultures around the world tend to create a situation of repeated priming of mathematics as negatively stereotyped on female students, which eventually define their attitude towards the subject. The stereotypical attitudes likewise may affect female students' perceptions of their ability to study mathematics or pursue certain career paths (Frazier-Kouassi, 1999). This bias encouraged by society has translated to low enrolment of females in mathematics related courses at the University level of education (Salman, 2001; Salman, Yahaya & Adewara, 2011).

Many researchers assert that mathematics is considered a male dominated domain in which females tend to shy away (Fatade, Nneji, Awofala & Awofala, 2012; Awofala, 2011). Specifically, Ursini and Sanchez (2008) showed in a longitudinal comparative study that male students display more positive attitudinal change than female students under varied instructional settings. Yet, Spelke (2005) held that in-depth studies yield little support to these assertions. A common argument therefore, is that particularly within university programmes, new technology provides a good way to improve attitude towards mathematics across all gender (Gomez-Chacon & Haines, 2008). Barkatsas (2004) added that for learning

and doing mathematics, technology in the form of mathematical analysis tools and real world interfaces such as the cloud can assist students' problem solving, support exploration of mathematical concepts, provide dynamically linked representations of ideas and can encourage general metacognitive abilities such as planning and checking.

Effective mathematics learning involves active engagement, ongoing discourse and reflection in all actions within the context of mathematics instruction delivery. Communication and reflection are believed to stimulate modification or reorganization of previously held ways of thinking and acting, enabling abstraction and generalization (Reed, Drijvers, & Kirschner, 2009). Instruction techniques in mathematics education are expected to raise and sustain students' perception of their ability to attain good results and the assurance that they can handle difficulties in mathematics (Pierce, Stacey & Barkatsas, 2007). This mathematics confidence and self-efficacy serve to boost positive attitude towards mathematics education.

Basically, mathematics as a subject is full of automatic procedures that have to be mastered. Such procedures involved skillful manipulation of equations, a sense of logic and the careful approach to ensure accuracy (Iji *et al.*, 2013). This fact is a clear indication that in order to build favourable attitude towards mathematics education, effective delivery strategies are required. Such effective instruction strategy must harness the abundant benefits of available technology. Demystifying mathematics will entail classroom instruction that enables students to exert more choice over how they approach study, with the teacher acting as a guide rather than a director.

The flexibility of cloud services may lend the technology as a compactible tool in mathematics education. The utilization of cloud technology may offer students the opportunity to appropriately use ubiquitous wireless network to access, manage, integrate and evaluate information, construct new knowledge, and communicate with others in order to

participate effectively in the society (Partnership for 21^{st} Century Skills, 2002). With the aid of available cloud services, students can drive more personalized learning of mathematics, forming a positive and appropriate image of the subject (Artigue, 2012).

Present-day instructional delivery in mathematics education hinges on mathematical proficiency. Kilpatrick and Findell (2001) maintain that effective mathematics teaching and learning is said to be guided by the integration and balanced development of all five strands of mathematical proficiency. These five central focuses are conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Kilpatrick and Findell (2001) observed that the last strand, productive disposition, is the habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence, and one's own efficacy. This productive disposition could be enhanced in students through the adoption of methodologies that integrate the use of modern tools such as the educational cloud to develop learning skills.

Cloud services, as a set of modern tools in mathematics education, have the tendency to promote self-instruction. Self-instruction, according to the National Mathematics Advisory Panel Report (2008), points to a variety of self-regulation strategies that students can use to manage themselves as learners and direct their own behavior, including their attention. The educational cloud enables students to drive individualized learning via unrestricted access to infrastructure and content. Students stand to gain from online services from anywhere within the hotspot of the cloud architecture by conveniently accessing powerful web-based tools.

The cloud by its very nature allows mathematics education students, male and female alike, endless opportunities to engage in advanced researches and even in online entrepreneurial outfits. Uncountable research materials can be sourced from synchronized virtual libraries and other linked instructional content repository. This functionality of the cloud is gradually changing the way mathematics education students study and do research in

school. Cloud utilization must have deposited some measure of impact on the students' perception of mathematics education. If this impact exists, then it may contribute in bridging the gender gap attached to students' attitude towards mathematics education.

The cloud has come to stay in university education in Nigeria as a tool for hooking students to the information grid. Campuses across the country are already leveraging on the dividends of mobile and wireless technology, considering the ubiquity of smartphones and other computer devices among the present-day student population. The level of penetration of cloud services in public universities, particularly in Benue State, calls for an in-depth assessment of the extent of impact on learners' disposition towards mathematics education. It is against this backdrop that this study sought to investigate the impact of cloud services on students' attitude towards mathematics education in public universities in Benue State.

1.2 Statement of the Problem

Historically, mathematics teaching at the lower levels of education does not always allow students to develop favourable disposition towards the subject. Most students cultivated a wrong perspective of the difficulty of mathematics as a school subject. With this misconception strengthened by the deployment of instructional strategies that obviously stunt the growth of mathematical mastery, one of the outcomes of this poor orientation is the lack of mathematics confidence and engagement among mathematics education students. This call for worry among mathematics educators has led to the quest for technological augmentation in instructional delivery.

Gaining insights into students' attitudes and beliefs has been described as the most important and crucial step in understanding how the learning environment for mathematics is affected by the introduction of computers and other technology. Modern pedagogies of mathematics education lay emphasis on adoption of active-learning strategies that put students in charge of their own learning. Such instructional strategies entail the efficient

blend of technologies in the teaching and learning process. Cloud technology in particular lets both the teachers and students stay abreast of current issues in mathematics education while enriching the learning experience.

The ICT Directorates of public Universities are usually charged with the responsibilities of anchoring these cloud services. This provision of standard internet services must have influenced the way mathematics education students perceive their discipline. The issue then was, do the availability of cloud services in public universities in Benue State affect students' attitude towards mathematics education? Would its impact on attitude of mathematics education students be associated with gender?

1.3 Purpose of the Study

The main purpose of this study was to find out the impact of cloud services on students' attitude towards mathematics education in public universities in Benue State. Specifically, the study sought to:

1. identify the computer devices readily available among mathematics education students for accessing cloud services in public universities in Benue State.
2. ascertain the frequency of usage of cloud services by mathematics education students in public universities in Benue State.
3. find out the extent to which cloud services affect the mathematics confidence of mathematics education students in public universities in Benue State.
4. ascertain the extent to which cloud services affect the affective engagement of mathematics education students in public universities in Benue State.
5. find out the extent to which cloud services affect the behavioural engagement of mathematics education students in public universities in Benue State.
6. ascertain which gender is more affected by the use of cloud services among mathematics education students in the public universities in Benue State.

1.4 Research Questions

The following research questions guide the study.

1. What are the computer devices readily available among mathematics education students for accessing cloud services in public universities in Benue State?
2. How frequent do mathematics education students of public universities in Benue State make use of available cloud services?
3. To what extent do cloud services affect mathematics confidence of mathematics education students in public universities in Benue State?
4. To what extent do cloud services affect the affective engagement of mathematics education students in public universities in Benue State?
5. To what extent do cloud services affect the behavioural engagement of mathematics education students in public universities in Benue State?
6. Which gender’s attitude towards mathematics was more affected due to cloud services among mathematics education students in the public universities in Benue State?

1.5 Research Hypotheses

The following research hypotheses were formulated and tested at 0.05 level of significance:

1. There is no significant difference in the mean response of mathematics education students on how cloud services affect students’ attitude towards mathematics education in the public universities in Benue State.
2. There is no significant difference in the mean response of mathematics education students on how cloud services affect male and female students’ attitudes towards mathematics education.

1.6 Significance of the Study

The findings of this study may have serious implications to a wide range of stakeholders in the higher education sub-sector. These include students, mathematics educators, ICT directorates of public universities, management of public universities, and other researchers.

The students of public universities may have the benefit of understanding the scope of the educational Cloud Services. This will enable undergraduates and post-graduate students of the great citadels of learning make optimal use of the cloud which was essentially designed and tailored to their needs.

The findings of this study may encourage mathematics educators to incorporate emergent technologies in their instructional design. Such blends of strategies may encourage both the teachers and students to make more out of the learning process.

The ICT Directorates of public universities may see this study as a third party observation of their specialized skills, efforts and technologies. The findings of this study may help the Directorates to identify areas that require improvement and how to better reach their ever-increasing targets.

The outcomes of this study will also inform the management of public universities on the need to invest more in cloud technologies, not only to enhance their institutions' competitiveness, but to further pursue the mission and vision of their schools. Management could also gain insights into the extent of coverage of one of its major contribution to present-day generation of scholars and researchers.

The findings of this study will be of theoretical significance to instructional planners and researchers as it may provide them with useful research evidence on the role of cloud technology in higher education. Copies of this research work will be made available in the

library and will also be uploaded on the internet in an effort to make it reach the targeted beneficiaries.

1.7 Scope of the Study

This study concerned itself with finding out how cloud services on the attitude of students toward mathematics education in public universities in Benue State. Only undergraduates of mathematics education programme in these public universities were used for the study. Mathematics education programmes include study options such as Mathematics Education, Mathematics and Statistics Education, Mathematics and Computer Science Education, and Statistics and Computer Science Education.

Geographically, the study was limited to Benue State. The state is situated in the north central region of Nigeria.

1.8 Operational Definition of Terms

Public Universities: These are degree awarding higher educational institutions owned by the Government.

Cloud: A term referring to a large pool of easily usable and accessible virtualized resources such as hardware, networks, development platforms and services utilized remotely by the user.

Wi-Fi: Short for Wireless Fidelity, a radio networking technology generally used to connect PCs (or other devices) to a local network and often using the Institute of Electrical Electronics Engineers (IEEE) 802.11b protocols. Also referred to (with some variance) as WLAN.

WLAN: Wireless Local Area Network, a radio technology used generally to connect PCs (or other devices) to a local network.

WMAN: Short for Wireless Metropolitan Area Network, a radio network that is larger than a WLAN, either in terms of geographic coverage or subscriber capacity. WMAN access might be offered across a community or city.

Access Point: A WLAN transmitter/receiver that generally acts as a bridge between a wireless network and a wireline network. It can also, however, act as a wireless bridge between multiple wireless networks.

802.11b: A specific wireless technical specification for use in the 2.4 GHz Industrial, Scientific and Medical (ISM) bands. 802.11b is currently the most popular specification and is popularly known as Wi-Fi. The 802.11 family were developed by working groups of the Institute of Electrical and Electronics Engineers (IEEE).

2.0 LITERATURE REVIEW

This section reviewed literature that are related to the study. This was carried out under theoretical framework, conceptual framework, empirical study and the summary of the literature review as discussed below.

a. Theoretical framework

i. Piaget's Theory of Cognitive Development.
ii. Vygotsky's Theory of Social Development.
iii. Expectancy-Value Model of Behaviour.
iv. Information Processing Theory of Learning.

b. Conceptual framework

i. Educational Cloud Services.
ii. Higher Education.
iii. Mathematics Education.
iv. Attitude towards Mathematics.
v. Gender Differences and Attitude towards Mathematics.

c. Empirical Studies

d. Summary of Review

2.1 Theoretical Framework

Instructional theories have been seen as the conglomeration of small, incremental steps sequenced to link information in a logical order (Tennyson, 2010). Instructional theories entail active learner participation in responding to instructional stimuli with immediate feedback as a positive reinforcer. Instructional design models suited for modern instructional platform such as electronic learning (eLearning), mobile learning (mLearning), and the newly

emerged cloud learning (cLearning) requires a delicate balance between education and technology to provide a truly effective learning experience (Wang, Brown & Ng, 2011). Phillips, Kennedy and McNaught (2012) relate that the characteristics of a theory are that it is derived from empirical evidence or from other theories; that it can provide a generalized explanation of a phenomenon to the accuracy of the evidence, sometimes based on a model, framework or analogy, and it can predict the behaviour of another instance of the phenomenon. In regards to this study, Piaget's Theory of Cognitive Development, Vygotsky's Theory of Social Development, Expectancy-Value Model of Behaviour, and Information Processing Theory of Learning are reviewed.

2.1.1 Piaget's theory of cognitive development

Jean Piaget (1896-1980) was a biologist who originally studied mollusks but moved into the study of the development of children's understanding, through observing them and talking and listening to them while they worked on exercises he set (Joubish & Khurram, 2011). Piaget's theory basically states that children must continually reconstruct their own understanding through active reflection on objects and events till they eventually achieve an adult perspective (Gillani, 2013). To Piaget, intelligence is represented by how an organism interacts with its environment through mental adaptation (Lutz & Huitt, 2004). This adaptation is controlled through mental organizations or structures (schema) that an individual uses to represent the world, driven by a biological impulse to obtain balance (equilibrium) between those mental structures and the environment.

Generally, Piaget's work consists of two principal parts: first, his theory of adaptation and the process of using cognitive schemes; second, his theory of cognitive developmental stages. The first aspect deals with the concepts of schema, assimilation, accommodation, and equilibrium. The second aspect posited four major stages of cognitive development that occur

over a lifetime, namely, sensorimotor, pre-operational, concrete operational, and formal operational.

Piaget's schemas are building blocks of intellectual development that adapts to environmental patterns as learners encounter new learning experiences (Anderson & Pearson, 1984). This adaptation occurs through assimilation and accommodation and is predicated on the belief that building of knowledge is a continuous activity of self-construction (Lutz & Huitt, 2004). Assimilation itself is the cognitive process which integrates new patterns, data, or processes into their existing schemata (Gillani, 2003). As a person interacts with the environment, knowledge is invented and manipulated into cognitive structures.

According to Piaget (2001), the change that occurs in the mental structure of schemata is called accommodation. When discrepancies between the environment and mental structures occur, either the perception of the environment can be changed to allow for new information, or the cognitive structures themselves can change as a result of the interaction through accommodation. Series of related assimilations and accommodations results in equilibrium, a balance between mental schemes and the requirements of the environment (Lutz & Huitt, 2004).

The combination of maturation and actions to achieve equilibration advances an individual into a higher developmental stage. Basically, a stage is a period in a child's development in which he or she is capable of understanding some things but not others (Joubish & Khurram, 2011). According to Piaget, the sensorimotor stage (Birth to 2 years old) begins with the reflex actions of infants and proceeds through the development of basic concepts such as time, space, and causality. The sensorimotor stage ends with the beginning of symbolic thought in the child. The Pre-operational stage (2 to 7 years) is characterized by the development of symbolic thinking and language.

The concrete operational stage (7 to adolescence) is marked by a significant increase in the child's ability to analyze and classify patterns according to the attributes of events and objects (Gillani, 2013). At this stage, children attain the cognitive ability of reversal and generalization. The formal operational (adolescence to adult) is marked by the ability to handle abstraction. Individuals at this stage can control variables systematically, test hypotheses, and make inferences.

One focal fact that emerges from an in-depth study of Piaget's work is the provision of frame of reference by which educators and educational technologists can analyze the behavior of the learner and design instructional environments within which students can control their own knowledge (Gillani, 2013). Piaget's theory of cognitive development as a philosophical and theoretical foundation provides answers to the questions of "why" and "how" specific pedagogy, including the application of cloud technology in learning, should be employed (Doolittle & Hicks, 2003). The cognitive constructivist world view dictates that the search for knowledge is the search for how the world really works and the value of knowledge is determined by its correspondence with the real world (Prawat & Floden, 1994). Utilization of cloud services is an indication of this quest by students to enrich knowledge and construct true cognitive structures.

The use of cloud services by mathematics education students is predicated on the framework of the learners' prior knowledge and experience. Piagetian cognitive constructivism provides that cognition is an active process of organizing one's prior knowledge to make sense of one's experience with the aim of constructing personal meaning, competence, and relationships (Wilson & Parish, 2010). Cloud services therefore present a convenient platform for connecting prior knowledge to new knowledge as a basis for establishing personal and social meaning. Studying via educational cloud services creates a lasting impression on students and the experience leads to conceptual shifts allowing complex

and related information to be better organized, integrated, and meaningfully connected to action.

Technology is viewed as a tool that allows the development of environments or educational platforms (such as provided via cloud services) in which individuals in the formal operational stage (e.g. mathematics education students) go through interacting with its elements to construct their own knowledge (Gillani, 2013). Cloud services open great doors that help students develop a sense of independent enquiry, productivity in creative thinking, and skills for analyzing information (Gillani, 2003). Piaget's theory of cognitive development also hinted at the satisfaction of maturation (Lutz & Huitt, 2004) which results in positive shift in interest, values, or attitudes towards the subject matter in students.

2.1.2 Vygotsky's theory of social development

Learning is an active process of constructing rather than acquiring knowledge. Knowledge itself is not just a mental state, rather it is an experienced relation of things, and it has no meaning outside of such relations (Hung, 2001). This constructivist orientation informs instructors to create learning environments that provides opportunities for students to create or construct knowledge (Bucci, Copenhaver, Lehman & O'Brien, 2003).

The Social Development Theory emerged out of the work of Russian psychologist Lev Vygotsky (1896-1934), largely unknown until it was published in 1962 (Sjoberg, 2007). The theory was propounded by Vygotsky in 1925 in his dissertation titled The Psychology of Art. Broadly, the Social Development Theory states that social interaction precedes development. It holds that consciousness and cognition are the end product of socialization and social behavior.

Vygotsky's theory asserts three major themes. First it holds that social interaction plays a major role in the process of cognitive development. Vygotsky (1978) states that every

function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (inter-psychological) and then inside the child (intra-psychological). The belief is that most learning takes place in a social context, and is facilitated by the interactions that students have with others (Berge, 2002).

The second theme of Vygotsky's work is the idea of the More Knowledgeable Other (MKO). The MKO refers to anyone who has a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The MKO could be a teacher, a coach, an older adult, more capable peers, or even computer technologies (Swan, 2005). These stakeholders in the education of the child act guides in the learning process.

The third paradigm of the social development theory is the notion of the Zone of Proximal Development (ZPD). The ZPD is the distance between a student's ability to perform a task under adult guidance and/or with peer collaboration and the students' ability in solving the problem independently. According to Vygotsky (1978), learning occurs in this zone. During the assistance process, individual is "other regulated" by a more capable peer or an adult. The individual, by means of this assistance, is able to move through series of steps that eventually lead to "self-regulation" and intellectual growth (Jones & Brader-Araje, 2002). From Vygotsky's standpoint, the ZPD are functions "buds" of development, not the "fruits" of development. The "fruits" refers to already learned knowledge that exists in the zone of actual development (ZAD). Churcher, Downs and Tewksbuary (2014) relate that Vygotsky redefine learning as an expansion of the ZPD into the ZAD.

Constructivism's perspectives on the role of the individual, on the importance of meaning-making, and on the active role of the learner are the very elements that make Vygotsky's social development theory appealing to educators (Jones *et al.*, 2002). For Vygotsky, the culture the child grows up and provides the cognitive tools needed for development. The type and quality of those tools determine, to a much greater extent, the

pattern and rate of development. Adults such as parents and teachers are conduits for the tools of the culture including language. The tools the culture provides a child include cultural history, social context, and language. Today they also include electronic form of information access such as the cloud.

If Vygotsky is correct and children develop in social or group settings, the use of cloud services to connect rather than separate students from one another would be of appropriate use. According to Jones *et al.*. (2002), the constructivist focus on the social context and larger community of learners has resulted in a major shift away from individually-based instruction to strategies that incorporates and embeds teaching within the larger community of peers, younger students, as well as those who are older. The theory of social development implies that learning is strengthened by environments accessed via cloud services which support and value the participation of all students, whose social norms encourage collaboration, the negotiation of meaning, and the search for understanding, and in which multiple perspectives are respected and incorporated into collective meaning making (Swan, 2005).

Cloud services build a high degree of engagement by leveraging Vygotsky's social cognitive development theory and interaction with content. The ability to learn through dialogue and interaction with others is central to knowledge generation (Churcher *et al.*., 2014). The benefit of using cloud services in mathematics education is the connectivity with which students spend much of their time, thus creating virtual communities of practice and virtual sphere for discussion and debate (Wenger, White & Smith, 2009). With this connectivity, the role of the instructor becomes that of moderating the trajectory of user-generated content and community knowledge sharing.

A constructivist teacher creates a context for learning in which students can become engaged in interesting activities that encourage and facilitate learning. Students tackle

problems, engage in adventures and challenges that are rooted in real life situations. Vygotsky's work establishes that the use of cloud services make learning primarily a process of enculturation which enhance students' attitude towards study (Swan, 2005). Students using cloud services are actively linked to authentic and applicable projects and problem solving situations.

2.1.3 Expectancy-value model of behaviour

The Expectancy-Value Model (EVM) has emerged as a model for understanding and predicting behaviour in the process of adopting innovations (Wozney, Vankatesh, & Abrami, 2006). Cloud service delivery within the education system must have a form of appeal as evidenced in its widespread integration by students and teachers alike.

The Expectancy-Value Model in its present state was developed by Jacquelynne S. Eccles and her colleagues in the early 1980s. In this model choices are assumed to be influenced by both negative and positive task characteristics, and all choices are assumed to have costs associated with them precisely because one choice often eliminates other options (Eccles & Wigfield, 2002). As a result, the relative value and probability of success of various options are key determinants of choice.

Proponents of EVM posit that students' beliefs about how well they will do on a task (called Expectation for Success) and how they value that task (called Subjective Task Value) are related. They theorize that students' Expectation for Success and Subjective Task Value (STV) predict their achievement outcomes and that students are more likely to engage in tasks, including supporting their studies with cloud-sourced materials, that they value and in which they expect to do well (Ramirez, Emmioglu & Schau, 2010).

The most recent visual representation of EVM is depicted in Figure 1. Expectancies and values are assumed to directly influence performance, persistence, and task choice.

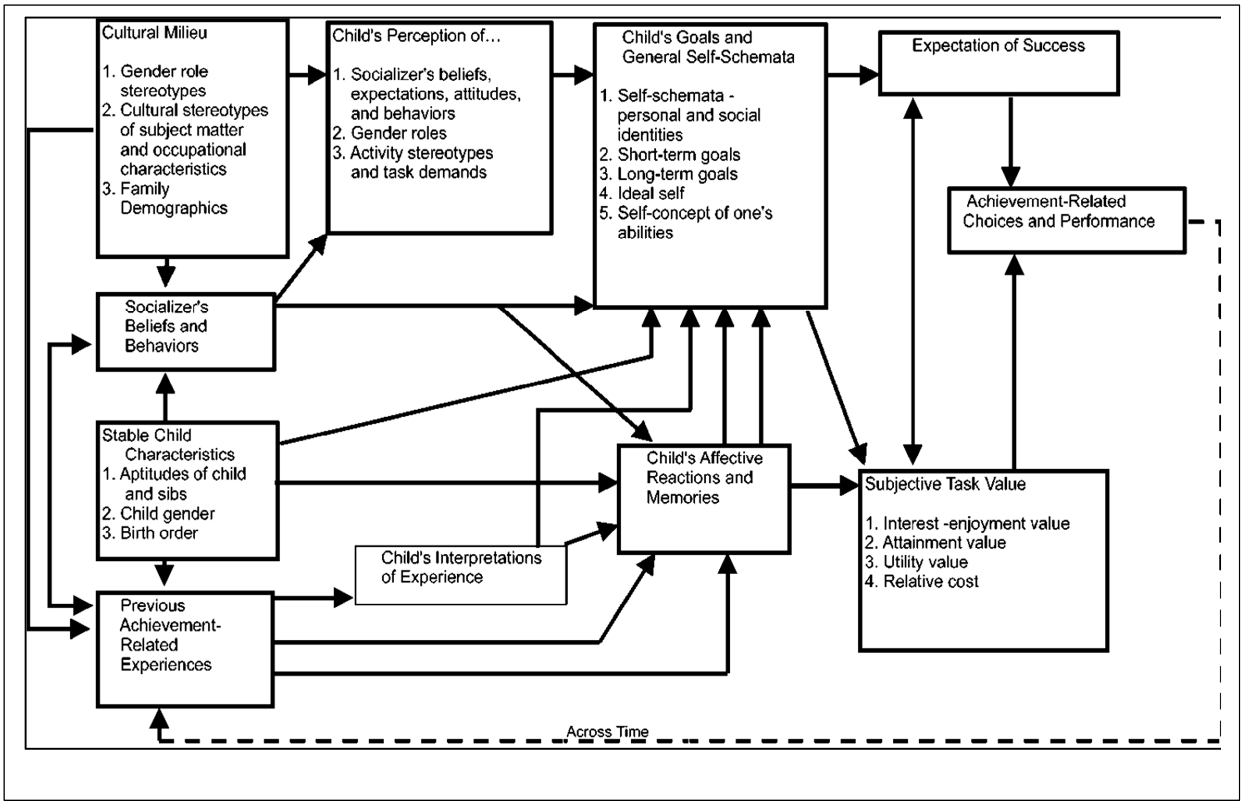

Figure 1: Expectancy-Value Model (Source: Eccles & Wigfield, 2002)

Expectancies and values are assumed to be influenced by task-specific beliefs such as perceptions of competence and difficulty of different tasks, and individual's goals and self-schema. According to Eccles, Adler, Futterman, Goff, Kaczala and Meece (1983), ability beliefs are conceived as broad beliefs about competence in a given domain.

EVM outlined four component factors of Subjective Task Value. These are Attainment Value, Intrinsic Value, Utility Value, and Cost (Eccles *et al.*, 1983). The importance a student attaches to the task is called Attainment Value. Intrinsic value is the students' interest in or enjoyment from engaging in the task. Utility Value links the usefulness of the task to the students' future goal such as their careers. The relative cost factor refers to why a student might try to avoid the task, for example, fear of failure, task difficulty, or math anxiety.

According to this model, Expectation for Success are positively influenced by high Attainment, Intrinsic and Utility values, while high cost imposes a negative influence (Ramirez *et al.*, 2010). These important values are set of stable, general beliefs about what is desirable, which emerge from both society's norms and the individual's core psychological needs and sense of self (Feather, 1988). As such, values are one class of motives that lead individuals to perform acts they think should be done (Eccles *et al.*, 2002).

Consequently, the Expectancy-Value Model is one of the most structured models in psychology to predict attitude by measuring attitudinal attributes and relevant external variables (Zhang, Xie, Wee, Thumboo & Li, 2008). Students' choice of additional study strategies like accessing educational cloud services for study materials are embedded in the values they placed on such alternatives. Students tend to spend more time in self-initiated study of mathematics via available cloud services because they find personal meaning and relevance in such interconnectivity (Hulleman & Harackiewicz, 2009). The expectations for

success in the study of mathematics provide purposes, or reasons, for task and effort while engaged in the activity.

The use of cloud services in universities by students of mathematics education constitutes an innovation with enormous potentials for both instructors and students. According to the Expectancy-Value Model, innovations are more likely to be adopted if the perceived value of the innovation and the likelihood (or expectancy) of success are high, as well as if these benefits outweigh the perceived costs of implementation (Wozney *et al.*, 2006). Obviously, usage of cloud services by mathematics educators and students enjoys high attainment, intrinsic and utility values at very low relative cost. That is to say, teachers' and students' decisions to use an innovation such as cloud services to augment classroom instruction delivery relate to (a) how highly they value the innovation; (b) how successful they expect their application of the innovation to be; and (c) how highly they perceive the relative cost of implementation.

The intrinsic value component of the use of cloud services by mathematics education students in universities points to a single fact: motivation. Motivation arises out of interest and grows into a positive disposition toward the study of mathematics. Hence, the Expectancy-Value Model of behavior boldly indicates the development of positive attitude towards mathematics education inherent in the utilization of educational cloud services.

2.1.4 Information processing theory of learning

The world is complex, and yet people are able to make some sense out of it. One of the most important tools people use to attain this feat is schema. Basically, a schema is a pre-existing assumption about the way the world is organized (Axelrod, 1973). When new information becomes available, a person tries to fit the new information into the pattern of previous interpretation.

The Information Processing Theory of Learning, also known as Cognitive Information Processing (CIP), emerged in the 1950s when psychologists began to express interest in the interior mental processes rather than the observable exterior views that behaviourism held. The theory as propounded by Atkinson and Shiffrin (1968) compares the human to the computer. This comparison is used as a means of better understanding the way information is processed and stored in the human mind. CIP views learning to represent the process of gathering information and organizing it into mental schemata (Kandarakis & Poulos, 2008). Memory, in terms of CIP refers to the persistence of learning that can be accessed at a later time.

Atkinson and Shiffrin (1968) maintained that information coming from the environment is processed by a series of temporary sensory memory systems (a part of the process of perception), and then fed into a limited capacity short-term store. The short-term memory, otherwise known as the Working Memory, is a system for holding information and allowing it to be used to perform a wide range of cognitive tasks, including transfer into and retrieval from long-term memory (Kandarakis & Poulos, 2008). The sensation received from the environment by the sensory memory is often lost with the passage of time through decay, while forgetting of information in the short-term memory results from displacement, occasioned by piling of additional new information. Loss of information in the long-term memory occurs due to interference of different packets of schema (Suthers, 2014).

One of the fundamental principles of Information Processing Theory is the basic assumption of a limited capacity of the mental system (Strauss, 2000). This implies that the amount of information that can be processed by the system is constrained in some very important ways. Bottlenecks, or restrictions in the flow and processing of information, occur at very specific points (Lutz & Huitt, 2003). To ensure effective learning, these bottlenecks have to be overpowered through vital information enriching procedures, thereby enhancing

attention, perception, rehearsal, response, encoding and retrieval. Utilization of cloud services by students to augment the learning process acts as a unique means of overcoming some of the bottlenecks in information processing.

Learning based on the framework of Information Processing Theory has a unique advantage: flexibility. Flexibility results in effective behavior and depends on remembering information at the right time (Kandarakis & Poulos, 2008). Also, the foundation of CIP rests on how humans learn. How one learns, acquires new information, and retains previous information guides selection of long-term learning objectives and methods of effective instruction (Lutz & Huitt, 2003).

The need to make information very meaningful is the focal point of the Information Processing Theory of Learning. Teachers are encouraged to incorporate into the instruction process elaborative strategies that develop meaningful context involving learning of fundamentals or representative ideas at the application level (Pham, 2011). The instruction process must encompass available technologies that will help impose order and connections in new information, expand on existing schemas, and put the learner in the most active (not passive) role possible in making connections. Cloud services offer the automaticity required by students to overlearn information or operations to the point where they can be used with little mental effort.

CIP emphasizes the volatility of human sensory memory system. The theory requires instructors to cue students to focus their selective attention to what is most important. Echoic (auditory) information must be supported by relevant iconic (visual) representation (Sorden, 2012). Successful learning occurs when learners build mental representations from these words and pictures and pictures (Mayer, 2005). As a viable tool for enriching instructions even beyond the classroom, the cloud is a vehicle for integrating both the verbal and pictorial models with prior knowledge in the long-term memory.

The cloud also provides access to relevant resources that will enable learners to carry out maintenance rehearsal within the working memory. The cloud allows for repetition of information over and over, thereby increasing the chance it will make it into long-term memory.

Based on the Information Processing Theory of Learning, we may say that memory is a perceptually active mental system. It receives, encodes, modifies, retains and retrieves information. Forgetting of vital information is caused by numerous factors including natural decay, displacement, interference, lack of organization and shortage of retrieval cues. This is where educational cloud services play pivotal roles as easy avenues for recoding. Cloud services are available as on-demand reference points for the mathematics education student to fall back on. With periodic augmentation of the learning experience, cloud services contribute to enhanced cognition and attendant attitude moderation among mathematics education students in Nigerian universities.

2.2 Conceptual Framework

2.2.1 Educational cloud services

Computing is undergoing a seismic shift from client/server to the cloud, a shift similar in importance and impact to the transition from mainframe to client/server (Harms & Yamartino, 2010). Cloud computing is an evolving term that describes the separation of application and information resources from the underlying infrastructure, and the mechanism used to deliver them. Cloud enhances collaboration, agility, scaling and optimized services (Cloud Security Alliance, 2009).

According to the National Institute of Standards and Technology (NIST) (as cited in UNICOM Government Inc, 2009), cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks,

servers, storage, applications, and services) that can be provided with minimal service provider effort. Typically, cloud services run in a web browser requiring the user to have only basic components while enjoying high speed, bandwidth and computing power. This simplicity is why the emergence of cloud services is fundamentally shifting the economics of IT-based businesses (Harms & Yamartino, 2010).

Education has not remained unaware of this trend in migration to the cloud (Niharika, Lavanya, Murthy & Satya Sai Kumar, 2012). Presently, virtualized resources are being provided to educational institution over the internet, without users having knowledge of, expertise in, or control over the technology infrastructure. More students are enriching their educational experience daily through network access provided by private cloud services.

To grasp the extent of utilization of cloud services in education, it is important to briefly study the acceptable architectural model of cloud computing.

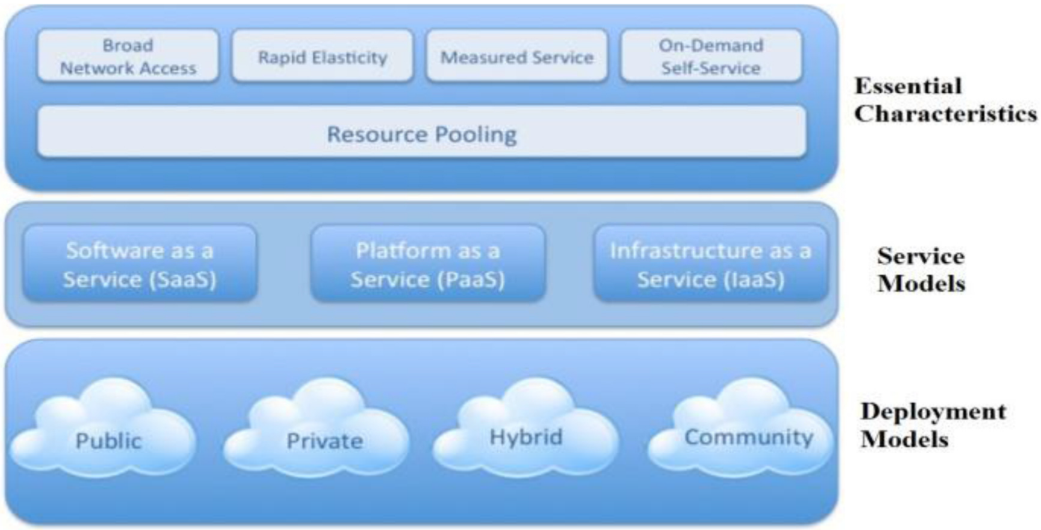

Figure 2: NIST Visual Model of Cloud Computing Definition (*Source: Niharika et al., 2012)*

Essential characteristics

Most commentators on cloud computing agree on five key characteristics

i. Broad Network Access: Services are provided over the network and accessed through standard mechanism.

ii. Rapid Elasticity: The cloud gives the user the impression that the services are infinitely scalable. The service needs to be available all the time and it has to be designed to scale upward for high periods and downward for lighter ones (Hurwitz *et al.*, 2010).

iii. Measured Service: A cloud environment has built-in system that bills users. In educational institutions such as the public universities in Benue State, students are given a number of hours daily to access the cloud, logging in with their user accounts as created on the university portal after payment of tuition fees.

iv. On-Demand Self-Service: The cloud allows the user to request an amount of computing facility needed automatically, without requiring direct human interaction with a service provider.

v. Resource Pooling: Computing services such as storage, processing, network, bandwidth, and virtual machines are dynamically assigned and reassigned according to the user's demand.

Cloud service models

Cloud service delivery is divided into three models. They are infrastructure as a service, platform as a service, and software as a service.

Infrastructure as a Service (IaaS) is the delivery of computer hardware for customized needs of the user. Such computer hardware include resources like servers, networking

technology, storage, and data centre space. Educational institutions benefit maximally from networking technology (wireless network) and access to servers.

Platform as a Service (PaaS) is the capability provided to the user to deploy onto the cloud user-created or acquired applications created using programming languages and tools supported by the provider.

Software as a Service (SaaS) implies the provision of applications which are accessible to users from various client devices through a thin interface such as a web browser. The private cloud service of the University of Agriculture Makurdi offers web-based email, virtual library, among other application services.

Cloud deployment models

The NIST recognizes four deployment models for cloud services.

i. Public Cloud: The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services. Popular examples are the Amazon Cloud and Google Cloud.
ii. Private Cloud: This cloud infrastructure is operated solely for a single organization. It is managed by the organization or a third party, and may exist on-premises or off-premises. The ICT Directorate of the Universities power the private cloud service on-premises, and serves the entire university community.
iii. Community Cloud: This cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns.
iv. Hybrid Cloud: This cloud infrastructure is a composition of two or more clouds that remains unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g. Cloud bursting for load-balancing between clouds).

The wireless network technologies in universities

Considering cost and technical factors, higher educational institutions are seeking private cloud services to provide a common interface, common identity infrastructure, and common service attributes (Katz, Goldstein & Yanosky, 2009). Universities are turning into network hubs, as mobile devices are carried by students and staff, and these devices are communicating with the world around them (Steijaert, Boyle, Leinen, Melve & Mitsos, 2012). Educational institutions are responding to the availability of cloud services by enforcing the use of a limited set of services such as official e-mail, internal university portal, and e-library services. Users are increasingly connecting to the wireless network on campus.

One of the primary requirements for benefiting from the wide range of services rendered by the university cloud is access to the school's wireless network. The term "wireless network" refers to two or more computers communicating using standard network rules or protocols, but without the use of cabling to connect the computers together (Bakardjieva, 2014).

For a telecommunications network to work, connectivity needs to be ensured at different levels by the elements present (Neto, 2004). The wireless network is basically a system of radio technologies deployed in the 2.4 GHz and 5 GHz bands.

Best (2003) presented a hypothetical network installation as depicted in Figure 3.

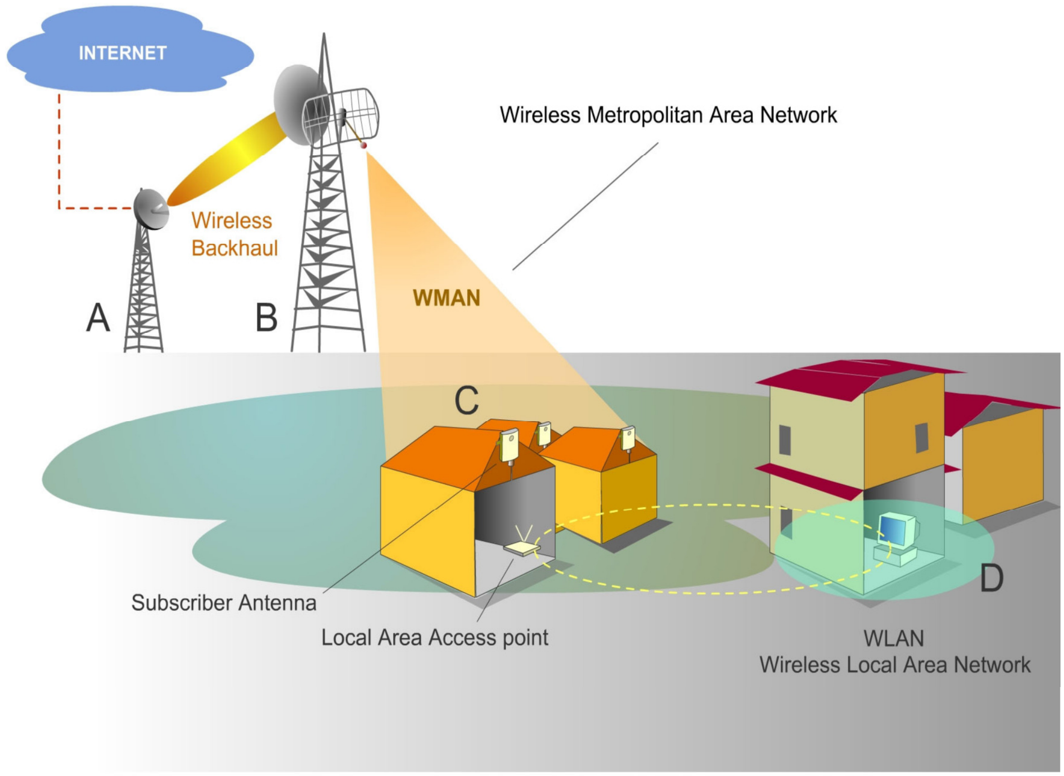

Figure 3: Connectivity in Wireless Networks (*Source: Best, 2003)*

This schematic diagram shows two radio towers (A and B), houses and other buildings (C), and a personal computer inside a building (D). Radio tower A is connected through a wired link to an Internet Point of Presence owned by an Internet Service Provider (ISP). The ISP radio tower could belong to any of the telecommunications companies with presence in the university (e.g. Airtel, Glo, Etisalat, or MTN). So, the PC shown at point D is ultimately connected to the Internet by several wireless links.

To start with, a point-to-point connection is used between radio towers A and B, with only one antenna (i.e. one receiver/transmitter) in both extremities. According to Neto (2004), the purpose of this connection is typically to transmit over long distances (in the order of tens of kilometres). Several of these links can be used, one after the other; in this way the signal will be transmitted, in "hops", to a potentially remote location. This is normally referred to as wireless backhaul.

The connection from B to C is a point-to-multipoint connection. This means that radio tower B is now radiating to and receiving from several stations of type C – i.e. several buildings with base stations, or access points. This is normally called a Wireless Metropolitan Area Network (WMAN) (Neto, 2004).

Finally, there is a radio connection between the subscriber equipment mounted on the side of the building (point C) and the individual personal computer inside the building (point D). This is what is normally called a Wireless Local Area Network (WLAN). An outdoor repeater may be required to redistribute the signals from the access point in a situation where there are blockages in the direct line of site (LOS) between the base station (access point) and the personal computer (PC).

For a PC to access the wireless network, it must possess a network interface card (NIC) or a network adapter card. Most modern laptops and mobile devices come with in-built network cards. Such Wi-Fi enabled systems can track signals from base stations available at

the offices of the Deans of the various colleges/faculties of the university. The usual transmitting proximity ranges from 100 metres indoors to 350 metres outdoors (Bakardjieva, 2014).

Cloud architecture for university

According to Mircea and Andreescu (2011), the architectural pattern of using cloud computing in universities may be described starting from the development and supply of services and resources offered to the university community. This may be illustrated as in figure 4.

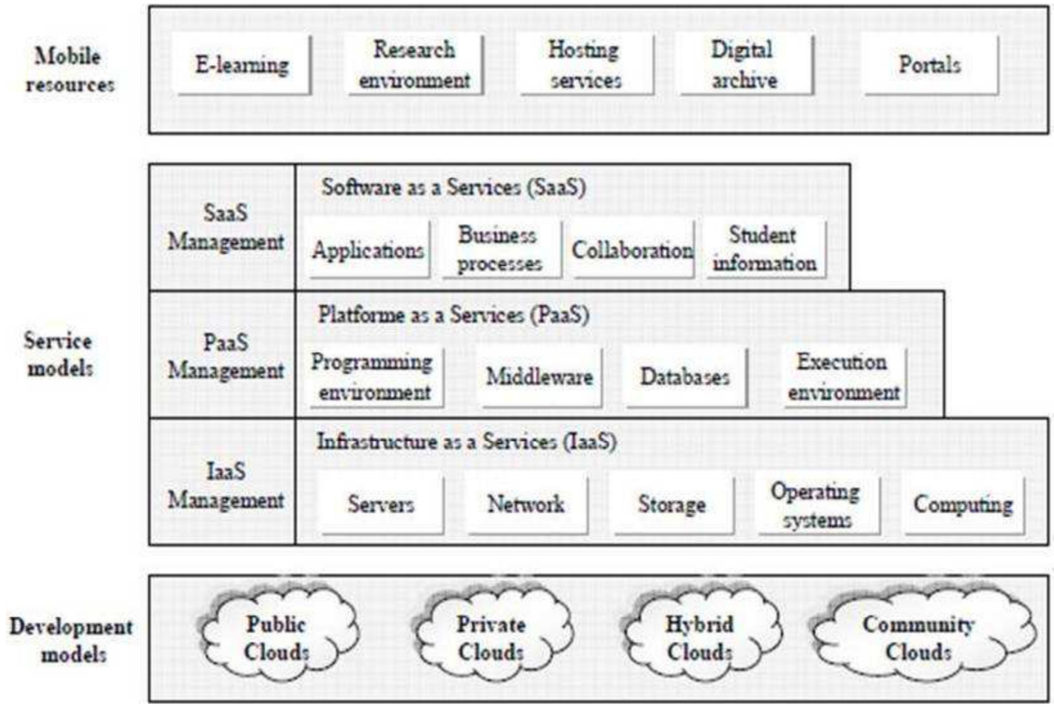

Figure 4: Cloud Architecture for University (*Source: Mircea & Andreescu, 2011)*

As shown in Figure 4, students and staff benefit from mobile resources as e-learning, expanded research environment, e-mail hosting services (for instance @uam.edu.ng), digital archive and student portal services. The services models indicate areas of direct impact of the three service models of cloud computing. The widest area of impact is the availability of wireless Internet network as a service.

Benefits of the cloud to students

Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and services) which can be dynamically re-configured to adjust to a variable load (scale), allowing also for optimum resource utilization (Vaquero, Merino, Caceres & Lindner, 2009). This pool of resources is typically exploited by a pay-per-use model which the infrastructure provider offers through customized Service Level Agreement. At the Universities, the infrastructure provider is the ICT Directorate of the institutions.

The goal of utilizing the cloud as a tool is the achievement of virtual communities of educators, researchers and practitioners working in collaborative groups to advance their practices (Thomas, 2011). Students stand to gain from online services from anywhere within the hotspot and anytime access to powerful web-based tools. It lets both the teachers and the students to access, share and publish documents, class calendars or web pages (Miseviciene, Budnikas & Ambraziene, 2011).

There is also 24 hours access to infrastructure and content. The cloud by its very nature allows students endless opportunities to engage in advanced researches and even in online entrepreneurial outfits. Resource sharing, network speed and flexible access are all accompanying benefits of the cloud to students. The cloud services of the universities allow offline usage with further synchronization opportunities. Uncountable research materials can

be sourced from the National Virtual Library and other linked library services. This functionality of the cloud is gradually changing the way students do research in the school.

2.2.2 Higher education

Education has always been considered as a means through which a society communicates its norms, values, and morals to her young one to ensure active participation in the society (Iji *et al.*, 2013). Education imparts knowledge, teaches skills, and instills attitudes to the recipients (Ifenkwe, 2013). Singh (1991) maintained that in its widest sense, education is at a cross-roads of societal development and knowledge, and importantly, of dynamic change processes and the capacities to make choices.

Education is at the centre of social and economic development because it provides knowledge and skills, encourages new behavior and increases individual and collective empowerment. Edukugho (2012) observed that educational institutions exist to impart high level skills to a reasonable proportion of the workforce, developing the intellectual capability of individuals, engaging training of competent, honest, patriotic and responsible professionals needed virtually in all spheres of human endeavor. Intellectual institutions are knowledge generators, centres of innovation, and importantly, service centres for their communities, facilitating and promoting change and development.

Higher education is the education given after secondary education in universities, colleges of education, monotechnics and polytechnics. In Nigeria, the Federal Ministry of Education has the responsibility for the coherence of national policy and procedures and for ensuring that the States' policies operate within the parameters of the national policy as adopted to local needs (Moja, 2010). National co-ordination of policy at the political levels takes place through the National Council of Education, chaired by the Federal Minister of Education and includes all the State Commissioners of Education.

Responsibility for ownership of higher educational institutions is shared between the government, communities and private organizations. The administration of the higher education system is controlled and regulated by established commissions, such as the National Universities Commission, for universities. The country now adopts a uniform entry procedure to polytechnics, colleges of education, and universities, and this is conducted by the Joint Admissions and Matriculation Board (JAMB) (Ifenkwe, 2013). Thereafter, each institution adopts a selection examination (aptitude tests) for her candidates that were successful in the Unified Tertiary Matriculation Examination (UTME).

Basically, higher education is a means of developing one's potentials to its maximum and discovering lasting values. Okonjo-Iweala (2012) asserts that there is compelling evidence that the education attainment – both in terms of years of schooling and cognitive skills – is positively linked to earnings and productivity. Apart from the very obvious economic impact, the connections between education levels and attributes such as health status, civic participation, and longevity are well documented across both developing and developed countries (UNESCO, 2010).

Present-day education is reactive and future oriented. It is actively promotive of innovation and dynamically evolving social needs (Singh, 1991). Education has risen to become the fulcrum on which the competitiveness of the nation in the global community rests. Higher education, therefore, must be tailored towards success in communities and workplace. To attain success, emphasis must be placed on higher education that develops in the individual a high sense of global awareness; financial, economic and business literacy; civic literacy; and technological prowess (Partnership for 21st Century Skills, 2002). This calls for efficient integration of modern technology in strategies for communicating knowledge in general, and mathematics education in particular, to a new generation of students.

Ayeni and Dada (2011) observed that following universal trend in education, Nigeria has also adopted a policy of technology integration in her educational system with the view of preparing youths for global competitiveness and aligning educational institutions into centres of excellence on ICT. Higher education in Nigeria is not left out by the impact of digital culture in contemporary life. User-friendly digital technology like the Internet and accompanying tools have allowed for high level interactivity and refined learning. Heidi (2008) maintained that the contemporary life for higher education requires the ability to convey personal feelings and apply learning to situations in real life. Educational cloud services provide adequately for this approach to study, particularly in universities.

2.2.3 Mathematics education

Mathematics is the body of knowledge centred on such concepts as quantity, structure, space and change, and also the academic discipline that studies them (Osafehinti,2015). Mathematics can be described as an organized active thinking, which involves the search for patterns and relationship that may be expressed in symbols. It is an expression of the human mind that reflect the active will, the contemplative reason and the desire for aesthetic perfection. Mathematics is essential for the full comprehension of technological and scientific advances, economic policies and business decisions, and other complexity of social and psychological issues.

Mathematics education is a field of study concerned with the tools, methods and approaches that facilitate the practice of teaching and learning mathematics. Mathematics education, particularly at the higher education level, prepares students for quantitative and symbolic reasoning and advanced mathematical skills through general education, services, major and graduate programmes. Odili (2012) argued that mathematicians can be categorized into two groups; the mathematics educators and professional mathematicians. The mathematics educator is concerned with curriculum development, instructional development

and the pedagogy of mathematics. Mathematics education basically prepares students to become innovative mathematics instructors, professionally prepared to communicate mathematics to learners at all levels.

Mathematics educators see mathematics not simply as a body of knowledge or an academic discipline but also as a field of practice. According to Kilpatrick (2008) this is because they are concerned with how mathematics is learned, understood, and used as well as what it is, they take a comprehensive view. Mathematics education looks beyond applications to ways in which people think about mathematics, how they use it in their daily lives, and how learners can be brought to connect the mathematics they see in school with the mathematics in the world around them.

Mathematics education as a field of study has been charting the pathways for effective delivery of mathematics instruction since its inception over a century ago (Kilpatrick, 2008). The establishment of national school systems by countries necessitated massive training and re-training of teachers as professionals. This basic requirement leads to the gradual development of mathematics education as university subject. In Nigeria, the National Universities Commission (NUC) has approved and accredited mathematics education in diverse single and combinatory forms. As at January 2012, over fifty (50) universities within the country offers mathematics education programmes in combinations such as B.Sc.Ed Mathematics and Statistics, B.Sc.Ed Mathematics and Computer Science, B.Sc.Ed Statistics and Computer Science, B.Ed Mathematics, and B.Ed Statistics (National Universities Commission, 2012). This statistics cuts across public and private universities. Within these programmes, students are exposed to the realities of the modern classroom they expect to direct. Students of mathematics education are turned out as creative mathematicians who still have full role to play with cutting edge technologies adding further layer of innovative possibilities (Tall, 2014). Cloud services available to students of mathematics education

avails them several opportunities of becoming reflective guidance to children who are in dire need of survival in this new technological world.

2.2.4 Attitude towards mathematics education

Gaining insights into students' attitudes and beliefs is the most important and crucial step in understanding how the learning environment for mathematics is affected by the introduction of computers and other technology (Galbraith & Haines, 1998). Attitude itself is defined as the positive or negative emotional disposition towards a subject (Gomez-Chacon & Haines, 2008). It represents an emotional response, beliefs regarding the subject, and behavior towards the subject.

Specifically, mathematics attitude has been described as aggregated measures of liking or disliking mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless (Neale, 1969 as cited in Chapman, 2003). It refers to the way one uses general capacities that are relevant for mathematics (such as mental openness, flexibility when seeking solutions to a problem, reflective thinking), aspects which are all more closely related to cognition than affect (Palacios, Arias & Arias, 2014). Attitudes are learnt; they are moldable and may change with experience of the stimulus objects and with rules or institutions (Binder & Niederle, 2007).

Other perspective of literature considers attitude towards mathematics as being unique. Palacios *et al.* (2014) mentioned that attitude towards mathematics also refers to the valuation, the appraisal, and the enjoyment of mathematics, underlying the affective facet more than the cognitive one. Similarly, Ajzen (1988) described attitude towards mathematics as a predisposition to respond favourably or unfavourably to mathematics. This perspective, according to Abedalaziz, Jamaluddin and Leng (2013) implies that attitudes possess cognitive (beliefs, knowledge, and expectations), affective (motivational and emotional), and

performance (behavior or actions) components. In this regard, some works have found that students with better attitudes towards mathematics have higher perceptions of the utility of mathematics, denoting intrinsic motivation towards study (Perry, 2011); they have a better mathematical self-concept (Hidalgo, Maroto & Palacios, 2005); are more confident they can learn mathematics (Rusinov, 2012) and; especially, they display approach behaviours towards mathematics (Fennema & Sherman, 1976 in Pierce, Stacey & Barkatsas, 2007).

Several attempts to measure attitude towards mathematics have shed further light on the components of attitude. In a review by Palacios *et al.* (2014), it was observed that these components started out as broad aspects such as pleasure and fear of mathematics. These subscales were considered the extreme poles of the same continuum, leading to the introduction of factors like enjoyment of mathematics, value of mathematics, mathematical motivation and utility of mathematics. One vital contribution in identifying constituents of attitude towards mathematics came from Tapia and Marsh (2004). Their Attitude Towards Mathematics Inventory (ATMI) attempts to assess six aspects of attitude: confidence - self-concept, anxiety, utility – value of mathematics, motivation, enjoyment of mathematics, and parents' and teachers' expectations.

Engendering positive attitudes in mathematics education students is an implicit objective of many mathematics education programmes. Over the years, the disposition of students towards mathematics has been very discouraging (Saritas & Akdemir, 2009). This has been linked to the myth that mathematics is difficult and always hardly needed in life careers (Okafor & Anaduaka, 2013). Also, the fact that employment anxiety among higher education students has been on the increase, contributed to the negative attitude of mathematics education undergraduates towards the discipline.

Attitudes toward mathematics have the potential to be modified. Larsen (2013) observed that learning environment, teacher quality, and meaningful teaching methods have

been considered as factors of change in studies on modification of attitude. This implies that the introduction of technological tools into the learning environment to aid teaching and learning of mathematics has the potential to influence the way students view mathematics. A study by Dix (1999) generated results that support the efficacy of technological tools in modifying students' attitude towards mathematics. The study observed that the use of computer-based technology in mathematics does appear to positively influence student motivation. But the extent to which specific computer technologies improves students attitude towards mathematics education enjoys little coverage in the body of available literature. The role of cloud services, in particular, on students' attitude towards mathematics education in Nigerian public universities is yet to be verified.

2.2.5 Gender and attitude towards mathematics

Gender is a complex, dynamic force that affects every social interaction, including interactions in educational settings. Its effects are woven into educational outcomes, and at times contribute to complicated disparities (Doerr, 2011). Gender inequality in learning mathematics and science has continued to be a topical issue of global concern (Arigbabu & Mji, 2004) and many studies assert that males are better than females (Alexoponlou, 1997; Awofala, 2011). Some researchers attribute this assertion to intrinsic aptitude differences, a predisposition from birth (Baron-Cohen, 2003). Others hold that males show greater variability in inherent mathematical talent and therefore predominate in school mathematics (Nowell & Hedges, 1998). Fatade, Nneji, Awofala and Awofala (2012) added that a wide range of socio-cultural factors contribute to gender inequality in mathematics achievement and ability.

Despite speculated claims, the subject of gender difference is of grave concern with no clear cut answer as to the questions of sex disparities in mathematics (Halpern, Benbow, Geary, Gur, Hyde & Gernsbacher, 2007). After considering evidence from studies of infants,

children and adults, Spelke (2005) maintained that available data yields little support to these claims. The psychologist added that although research on older children and adults has revealed differences between the performance of males and females on specific cognitive tasks, her research provides no evidence for sex differences in overall aptitude for mathematics at any point in development. She further expounded that research on selected groups of highly talented students reveals some disparities in performance on speeded tests of quantitative reasoning, but highly talented male and female students also show equal abilities to learn mathematics.

Fatade *et al.* (2012) hold a different perspective. They assert that mathematics is considered a male dominated domain in which females tend to shy away. Males tend to "show a natural positive attitude to school mathematics while females display negative attitude" (p.105). The researchers concurred that the negative attitude is situated in the stereotypical belief which is a common phenomenon in Nigeria. Another perspective to mathematics attitudinal difference between males and females lies in school type. In this view, a cross-sectional study by Norton and Rennie (1998) along single-sex and co-educational school dichotomy indicated that there was no significant difference between the attitude towards mathematics among male and female students in co-educational schools. But there were small variations on the scales measuring effects relating to grade level and school type. The general observation, however was that overall, boys have more positive attitudes toward mathematics than girls.

In another study to investigate the attitude towards mathematics of male and female students in Nigeria, Adebule and Aborisade (2014) arrived at the conclusion that attitude of students towards mathematics did not depend upon sex. The researchers recommended that sex should not to be considered as a factor influencing attitude of student towards mathematics and that teachers should teach mathematics freely among all category of

students. This outcome is in agreement with the work of Lindberg, Hyde and Petersen (2010) who held that due to cultural shifts in recent years, the gender gap is closing. A close review of the trend indicates that the common denominator in the dynamics of educational change in recent times is computer technology. What does this blend of technological innovations into instructional strategies portrays for mathematics education? How does this trend impact on the attitudes of students towards mathematics?

When technological tools are introduced into mathematics instruction directly or indirectly, Dix (1999) found that differences in attitude between male and female students are significant. Longitudinal changes in attitude reveal a significant positive change in male attitude towards mathematics. Male students were more willing to experiment with technology. Stacey, Pierce and Barkatsas (2007) while testing their attitudinal scale also established that boys have statistically significant scores than girls for attitude to learning with technology.

A study by Ursini and Sanchez (2008) seeks to compare changes in girls' and boys' attitude towards computer-based mathematics. The longitudinal comparative spanning three years showed attitudinal change in students subjected to technology augmented mathematics instruction. Significant gender differences favouring boys were found in attitudes towards mathematics for the group using technology. Similarly, this present study extends the blend of technological tools such as the educational cloud in mathematics education, to observe the attitudinal impact on both male and female students in public universities in Benue State.

2.3 Empirical Studies

Higher education teachers and researchers in mathematics education seek ways to give life to the learning of mathematics by using technological innovations. A common argument is that within university programmes new technology provides a good way to improve attitude towards mathematics (Gomez-Chacon *et al.*, 2008). Technology provides an

enormous spectrum of possibilities for new approaches to teaching and hence for learning across all levels of education. Many research and professional literature suggests that new approaches such as utilization of cloud services in augmenting instruction may enhance learning through cognitive, metacognitive and affective channels.

Pierce, Stacey and Barkatsas (2007) in an attempt to develop scale for monitoring students attitudes to learning mathematics, polled 350 students from 17 intact classes across 6 secondary schools in Victoria (Australia). The intent of the study was to authenticate the Mathematics and Technology Attitude Scale (MTAS). The MTAS was built from a cross-section of items meant to cover five attitude subscales, namely, Mathematics Confidence (MC), Confidence with Technology (TC), attitude to learning mathematics with technology (MT), Affective Engagement (AE) and Behavioural Engagement (BE). Reliability analysis yields satisfactory Cronbach's alpha value for each subscale (MC, 0.87; MT, 0.89; TC, 0.79; BE, 0.72 and AE, 0.65), indicating a strong or acceptable degree of internal consistency in each subscale. The results of the study indicate students gave maximum possible MT scores. In every school, most students agreed rather than disagreed that it was better to learn mathematics with technology. The researchers also established statistically significant difference between attitude towards mathematics of boys and girls. A breakdown of scores by gender reveals that boys have higher scores than girls for each subscales except for BE ($t = -0.005$, $df = 151$, $p = 0.996$). The differences are greatest for TC ($t = 6.84$, $df = 152$, $p = 0.000$) and MC ($t = 6.13$, $df = 155$, $p = 0.00$) with MT ($t = 2.85$. $df = 149$, $p = 0.005$) and AE ($t = 2.56$, $df = 152$, $p = 0.011$) demonstrating less difference. In interpreting all the gender differences, the researchers noted that only a few girls actually expressed negative responses to any of the factors, but there were more highly positive responses from the boys. Whereas boys may experience learning mathematics more positively simply because technology is present, some girls may value it when they feel it has the potential to compensate for self-perceived shortcomings. Although the work of Pierce, *et al.* (2007) refined an important

attitude scale, it failed to streamline the aspect of technology which elicits the positive attitude in students. This present work intends to narrow the technology integration to the utilization of cloud services. Also, the target sphere of this study is the university environment where individualistic learning approaches are encouraged.

In a mixed-method study carried out in the Netherlands by Reed, Drijvers and Kirschner (2009), 521 students were helped to elaborate, refine and develop their own construction process and object knowledge of functions using a designed computer tool. The study examined the relationships between attitudes, behaviours, and learning outcomes when using a computer tool. The study uses a 23-item questionnaire (Cronbach's alpha = 0.70) to generate scores on student attitudes and self-reported behaviours. The study employed mean and standard deviation in the analysis of data. A further detailed observation of a small number of students (N = 8) from two combined higher general/pre-university level classes used to test the designed tool, revealed that positive attitude towards mathematics and mathematical computer tools augmented exhibited learning behavours. A focal outcome of the study was the fact that promoting learning with computer tools needs to take several factors into account, including improving students attitudes, raising levels of learning behaviours, and giving sufficient opportunity for constructing new mathematical knowledge within mathematical discourse. The work of Reed *et al.* (2009) relates to this present research through its emphasis on improving students attitudes towards mathematics by introducing computer technology. However, the Dutch researchers deployed their designed computer tool to a rather too small sample (N = 8) out of the entire pool (N = 521) used in the general survey. The current work on the utilization of cloud services in mathematics education derives its strength from the ubiquitous availability of wireless cloud services to students.

Okai, Uddin, Arshad, Alsaqour and Shah (2014) conducted a study on cloud computing adoption model for universities. The researchers employ both interview and

questionnaire in a survey to develop a model for cloud computing adoption. Data was collected from experts who have adopted and implemented the cloud technology at Asia Pacific University of Technology and Innovation, Malaysia. The study tends to focus on the technicalities of cloud adoption more than its availability and utilization. The results of the study indicate 95% savings on number of servers when cloud services were adopted. Based on the outcome of the study, the researchers proposed a model which takes into consideration strategic guidelines to overcome security and privacy concerns, reliability concerns, and charting of a roadmap for successful adoption. The work of Okai, *et al.* (2014) brings to the fore component issues of cloud computing, which have been dealt with elsewhere in this present study. The researchers however failed to pinpoint any aspect of student utilization within the study area. There was no mention of students who are to be the larger proportion of beneficiaries of any cloud computing adoption efforts in the university. Also, the fact that only expert opinion was sought for the study betrays the evolving nature of the cloud itself. This present work encompasses the target end users of cloud services within universities and how such utilization improves the education of the students.

Wu (2013) embarked on a study to observe the difference between the learning behavior and attitude of students before exposure to IT education environment of cloud computing service and after exposure. The study applies a quasi-experimental design on 110 fifth grade students who were selected from Tunglo Elementary School in Miaoli county, Taiwan. Fifty-five of the students were placed in an experimental teaching spanning four weeks, one period per week. Before and after the four weeks experiment teaching, all participants had to fill out the “Scale of Using IT Education Environment of Cloud Computing” (Cronbach’s alpha = 0.953). Students were given user accounts to access cloud services hosted inside the school. The results showed the means of pretest and posttest of each scale was greater than the reference value. The t-test analysis ($t_{(92.395)} = 5.689$, $p = 0.000$, $MD = -1.830$) indicate that after using the cloud service, students had more positive attitude

towards using it, even after school. This study by Wu (2013) relates to the present work in its direct usage of cloud services in instruction. Also, the allocation of user accounts to students for cloud access is a similarity shared by both works. However, students used for the study are from a lower level education, and the subject of interest was IT education. This present work intends to poll the impact of using cloud services on the attitude of mathematics education students in public universities towards the subject of mathematics.

The work of Johnson and Hiran (2014) presented at the International Conference on Science, Technology, Education, Arts, Management and Social Sciences (iStEAMS) held at the Afe Babalola University, Ado-Ekiti in May, 2014, drew a comparative line for universities in Nigeria. The Ghana-based survey was designed to elicit information from a target population comprising IT administrators, faculty and students from four selected tertiary institutions. The sample for the study comprises of 50 respondents randomly drawn from among IT administrators, faculty and students in the four selected tertiary institutions. Structured questionnaire containing both open and closed-ended questions were used to obtain data on the usage, benefits and the constraints of cloud computing technology in higher educational institutions in Ghana. Data analysis for the study was carried out using frequencies, percentages and pie charts. Majority of the respondents constituting 76 % said that their institutions do not use any cloud service model while the rest of the respondents (24 %) said their institutions use at least one of the cloud service models. Out of the respondents whose institutions used at least one (1) cloud service model, the percentage of respondents according to service models are: SaaS: 40 %; PaaS: 30 %; IaaS: 22 %; and none: 8 %. This present research is in line with the work of Johnson and Hiran (2014) in its emphasis on all the cloud service models available to mathematics education students. Although the researchers sampled opinions from across several schools, their study was not field-specific. The specific impact of the services on students was not ascertained.

A recent study of students from two Nigerian universities by Olibe, Ezoem, and Ekene (2014) underscore the extent of awareness of available virtual learning channels in Nigeria. The researchers employs a descriptive survey design on a sample of six hundred and forty (640) 300 level students in the only two public universities in Anambra State. The study used a researcher-developed checklist titled “Students Virtual Learning Awareness Questionnaire” (SVLAQ). The study used frequencies and percentages in analyzing data obtained with the SVLAQ. The findings of the study indicate students were mostly aware of virtual learning channels such as educational blogs, online libraries, online self-paced course contents with inter-linkage support, and other alternative learning channels provided via connections to cloud networks. The study also noted a surprising incongruence in male and female students’ awareness of what constitutes virtual learning, with female students having more knowledge of virtual learning than male students. Olibe *et al.* (2014) recommended that lecturers need to incorporate virtual activities in curriculum delivery, task design processes and outcomes, teaching pedagogies, and measurements of actual learning. The work elaborately identified aspects of educational content assessed through available network services as covered by this present research on cloud utilization in public universities in Benue State. But the researchers drew their sample from across different disciplines, not expounding what the said awareness of virtual learning holds for individual fields of study such as mathematics education.

In a similar vein, Oyeleye, Fagbola and Daramola (2014) carried out a study to investigate the impact and challenges of the adoption of cloud computing by public universities in the southwestern part of Nigeria. A sample of 100 IT staff, 50 para-IT staff and 50 students each was selected from 10 public universities in the southwest. The researchers adopted a descriptive survey for the study. The study employed a structured questionnaire titled “The Evaluation of the Impact and Challenges of Cloud adoption and Use on Universities in Southwestern Nigeria.” The instrument has a Cronbach Alpha reliability

coefficient of 0.89. Frequency and percentage distributions were used to analyze collected data. The outcome of the study indicated a mere 10 % adoption of cloud computing by Nigerian public universities, with the service model distribution represented as PaaS: 20 %, IaaS: 10 %, and SaaS: 70 %. This distribution corroborates the report of Johnson and Hiran (2014) that the highest numbers of cloud consumers subscribe to SaaS. Still, this study fall short of specifics, not relating how students utilize the services directly in their course of study.

In another study, Adeyeye, Afolabi and Ayo (2014) in a study canvassing for enhanced academic standards affirmed that cloud networks are commonplace in Nigerian tertiary institutions and act as a good platform for distributing and disseminating instructional materials. The study, which employs a system analysis and implementation design, is a detailed presentation of the development of a virtual campus in Covenant University, Ota, Nigeria. All the students of the school's College of Science and Technology (CST) have access to personal computers, with 70 % having personal laptop (PCs). Students access the university cloud via wireless access points (hotspot zones) connected through a backbone network of fiber optics. The work seeks to improve quality through online provision of learning resources based on Free Open Source Software (FOSS), wired and wireless access to contents, discussion forum, and mail services. The researchers recommend efficient propagation of similar systems in higher educational institutions in Nigeria to reduce students' idle time and get them engaged in productive academic discourse. The study, however, left out the use of any programme within CST to test the efficacy of the virtual campus. Another obvious discrepancy between the work of Adeyeye *et al.* (2014) and this present study is the fact that the target school is a private university. This present work is subject-area-specific (mathematics education) and draws its sample from the domain of public universities.

2.4 Summary of the Review

This chapter basically seeks to review available relevant literature related to the study. Firstly, four fundamental theoretical foundations for the study were covered. The pioneering works of Piaget and Vygotsky were reviewed alongside Expectancy-Value Model of Behaviour and Information Processing Theory of Learning. These pivotal frameworks provides a pre-study structure requisite for understanding technology-aided instructional strategies as obtained in the deployment of cloud services to augment mathematics education.

Secondly, literature related to the focal concepts of the study was reviewed. The technology of educational cloud was given an extensive coverage. Higher education in Nigeria, mathematics education, attitude of students towards mathematics, and the role of gender in attitudinal changes in mathematics were also reviewed.

A third section of this review considered previous researches on the efficacy of technological tools deployment in education. The empirical studies indicated a shift in attitude towards mathematics among students when computer-based technologies were introduced into mathematics education, but with conflicting views on the factor of gender. A few works on educational cloud services in higher educational institutions were also reviewed, with none establishing any field-specific impact.

From the review of literature, it is clear that different forms of technological innovations enjoy different affective acceptance. This points to the fact that human-computer interaction is a complex phenomenon and the attitudes and feelings involved with the relationship are not easy to identify. As the role of computer technology expands in the global society, it is imperative that educators become aware of the anxiety of integration among students. Several researches considered so far indicate a high likelihood that students' attitude towards subject area like mathematics are generally boosted with the adoption of computer technology. However, as observed throughout this review, the body of available literature

holds little evidence of usage of technological tools such as educational cloud services in specific areas of studies like mathematics education. This present work on the impact of cloud services on students' attitude towards mathematics education in public universities in Benue State intends to bridge this gap.

3.0 METHODOLOGY

This chapter deals with method used in carrying out the study. This was done under the following sub- headings: Research design, area of the study, population of the study, sample and sampling technique, instrument for data collection, validity and reliability of instruments was established as well as methods of data collection and analysis.

3.1 Research Design

Ex-post facto research design was adopted for this study. The ex-post facto research design is a research in which the independent variable of interest has already occurred and in which the researcher begins with the observation on a dependent variable, followed by a retrospective study of possible relationship and impact (Emaikwu, 2011). The ex-post facto design was considered appropriate for the study due to its scope of coverage in explaining existing relationships and developing trends.

3.2 Area of the Study

The study was conducted in Benue State. The State is located in North Central region of Nigeria and borders with Nasarawa State to the North, Taraba State to the East, Ebonyi and Cross River States to the South, Enugu to the South West, and Kogi State to the West. The State stretches between longitude 7º 47´ and 10º 0´ East, and latitude 6º 25´ and 8º 8´ North. Benue State has a land mass of 33,955 square kilometers, with a population of 4,780,389 in 2006, now estimated at nearly five million (Thisday, 2012; Benue State Government, 2015). The State has three (3) senatorial zones and a total of twenty-three local government areas.

Benue State is home to several reputable higher educational institutions. These include Akperan Orshi College of Agriculture, Yandev; College of Education, Oju; Alfred

Akawe Torkula College of Advanced and Professional Studies, Makurdi; College of Education, Katsina-Ala; Benue State Polytechnic, Ugbokolo; Fidel Polytechnic, Gboko; University of Agriculture, Makurdi; Benue State University, Makurdi; University of Mkar, Mkar; and the National Open University of Nigeria's study centres in Otukpo and Makurdi.

The choice of Benue State for this study was based on the evidence from literature that students in Benue, like their counterparts from other part of Nigeria, display poor attitude towards mathematics right from the lowest to the highest educational levels (Achor &Tyavbee, 2014; Ibaishwa, 2014). Also, the choice was appropriate considering the global migration to an Information Age in which Benue as a State is not left out. The widespread deployment of mobile and wireless technology within the State is evident even by simple observation.

3.3 Population of the Study

The population of the study comprises all mathematics education students in public universities in Benue State. The target population size was 1807 students made up of 1242 students from the University of Agriculture, Makurdi; 437 students from Benue State University; and 128 students from the campuses of the National Open University of Nigeria in Benue State.

3.4 Sample and Sampling Technique

The sample comprises 328 mathematics education students drawn from the two out of the three public universities in Benue State having operational cloud service delivery systems. The sample size was arrived at by applying Taro-Yamane's formula for sample determination (Appendix D, p.115)

Multi-stage sampling was used for the study. Firstly, purposive sampling was used to select the only two public universities in Benue State which offer cloud services to students.

These are Benue State University Makurdi (BSU), and University of Agriculture Makurdi (UAM). Secondly, proportionate stratified random sampling was used to select 82 mathematics education students from BSU and 246 mathematics education students from UAM, resulting in a total sample size of 328.

3.5 Instrument for Data Collection

The instrument for data collection in this study was the Cloud Services Impact Questionnaire (CSIQ). The CSIQ is a researcher-developed instrument which comprises four (4) sections, A, B, C and D. Section A, tagged Basic Information, is meant to elicit responses on mathematics education students' institution, sex and study option.

Section B is a checklist tagged Computer Devices Used in Accessing Cloud Services. The checklist contains the various computer devices available among students for connecting to cloud services when in a Wi-Fi hotspot.

Section C of CSIQ provides responses on the frequency of usage of cloud services among mathematics education students. The item elicits response ranging from Very Frequent, Frequent, Fairly Frequent, to Not Frequent.

Section D is an attitude scale tagged Cloud Services Mathematics Attitude Scale (CSMAS). The CSMAS is a mathematics attitude scale adapted from a set of existing mathematics attitude scales including Modified Fennema-Sherman Mathematics Attitude Scale (Doepken, Lawsky, & Padwa, 1993), Mathematics and Technology Attitude Scale (Pierce, Stacey & Barkatsas, 2007), and Attitudes to Technology in Mathematics Learning Questionnaire (Fogarty, Cretchley, Harman, Ellerton & Konki, 2001). The CSMAS consists of 40 items, structured on a four-point scale of Very High Impact (VHI), High Impact (HI), Low Impact (LI), and Very Low Impact (VLI). The items of the CSMAS cover basic components of mathematics attitude such as mathematics confidence, behavioural

engagement, and affective engagement. Positive items were scored 4, 3, 2, and 1, for VHI, HI, LI, and VLI respectively. The scoring for negative items are reversed after the order 1, 2, 3, and 4, for VHI, HI, LI, and VLI respectively.

3.6 Validation of the Instrument

The validation of the instrument for this study was done by two experts in Mathematics Education and one expert in Measurement and Evaluation. The experts in Mathematics Education comprise of one each from University of Agriculture Makurdi and Benue State University. The expert in Measurement and Evaluation is from the University of Agriculture Makurdi. The experts were requested to vet the instrument based on face validity, simplicity of language, and appropriateness of the constructed items in respect of the objectives of the study. Based on the recommendations of the experts, necessary modifications were made to the instrument. The validation yielded a total of 40 items after an initial effort of 63 items was subjected to thorough scrutiny. For instance, items initially lumped together in Section A as Basic Information were separated into different sections in line with the research questions. Some items of the CSMAS were dropped while others were modified to reflect the relationship to cloud services. Another major outcome of the validation was the re-framing of the scale from the Strongly Agreed - Strongly Disagreed continuum into the Very High Impact - Very Low Impact continuum, to indicate the extent of impact of cloud services. Also, the frequency of usage was changed from Often to Frequent. The experts' comments, opinions, and suggestions used to design the CSIQ are displayed in Appendix B (p.107).

3.7 Reliability of the Instrument

To ensure reliability, the CSIQ was trial-tested on 50 mathematics education students at the University of Jos, Jos. University of Jos was used for the trial testing because it has a robust on-campus cloud service and is outside the study area. Results obtained from the trial

testing were subjected to reliability analysis yielding a Cronbach's alpha coefficients of 0.80 for the mathematics confidence sub-scale; 0.83 for the affective engagement sub-scale; 0.89 for the behavioural engagement sub-scale; and 0.92 for the summated CSMAS. The reliability analysis is displayed in Appendix C (p.111).

3.8 Method of Data Collection

The CSIQ was administered to mathematics education students in the sampled universities and collected by the researcher. The questionnaires were given to respondents directly by the researcher and were collected after the respondents must have conveniently responded to the items. Data collection was handled by the researcher considering the fact that the sampled universities are all located in Makurdi, the Benue State capital. This is also to avoid misplacement or non-completion of responses by the respondents.

3.9 Method of Data Analysis

Data were collected and analyzed using both descriptive and inferential statistics. The research questions were answered using simple percentages, pie charts, mean, and standard deviation. The research hypotheses were tested at 0.05 level of significance using the t-test. The t-test was used because it provides an appropriate measure of the statistically significant difference between two independent random samples from normal populations whose variances are not necessarily equal.

4.0 RESULTS AND DISCUSSION

This chapter deals with presentation of data, analysis, interpretation of results, and discussion of findings.

4.1 Presentation of Results

The presentation of data analysis and interpretation for this study was done according to the research questions and followed by related hypotheses.

4.1.1 Research question one

What are the computer devices readily available among mathematics education students for accessing cloud services in public universities in Benue State?

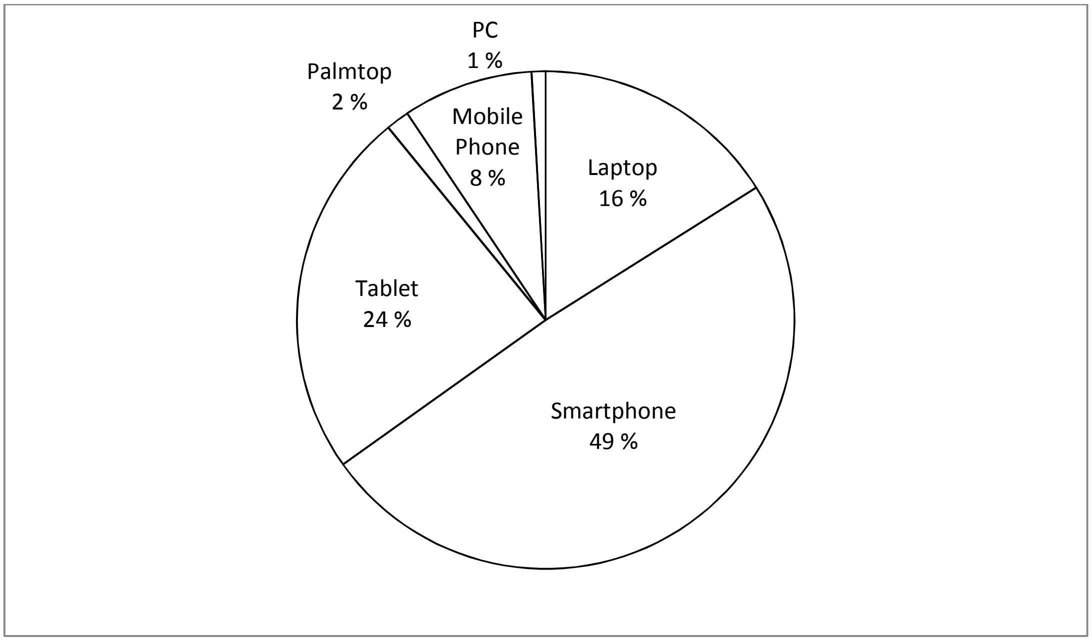

Figure 5: Computer Devices Used in Accessing Cloud Services

Figure 5 shows that smartphones (49 %), tablets (24 %) and laptops (16 %) are the prevalent computer devices readily available among mathematics education students for accessing cloud services. This shows a high level of penetration of hand-held devices over café-type personal computers (1 %) which used to be the norm.

4.1.2 Research question two

How frequent do mathematics education students of public universities in Benue State make use of available cloud services?

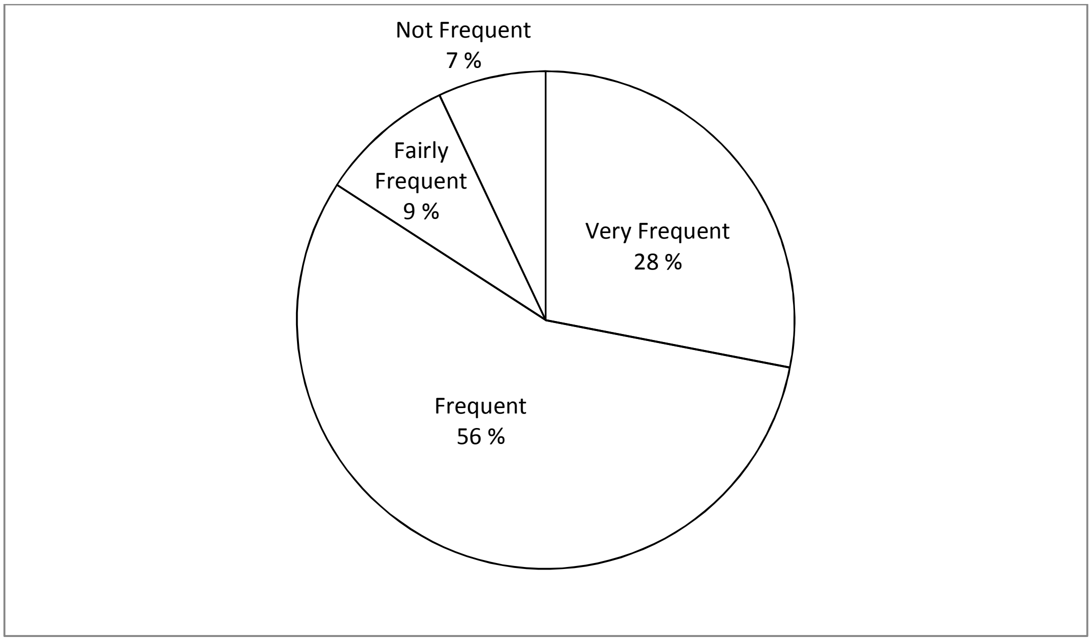

Figure 6: Frequency of Usage of Cloud Services

Figure 6 indicate that a high percentage of mathematics education students (56 % and 28 %) frequently access cloud services.

4.1.3 Research question three

To what extent do cloud services affect mathematics confidence of mathematics education students in public universities in Benue State?

TABLE 1: Mean Attitude Scores of Mathematics Confidence of Mathematics Education Students in Public Universities in Benue State

S/No.	Items	Mean	SD	Remark
1	I am sure that I can learn mathematics using cloud services.	2.63	1.09	High
2	Mathematics is hard for me even with the use of cloud services.	3.13	1.03	High
3	I find mathematics frightening even with cloud services.	2.78	1.00	High
4	I know I can handle difficulties in mathematics with the aid of cloud services.	3.47	0.87	High
5	It takes me longer time to understand mathematics than the average person even with the aid of cloud services.	3.81	1.01	High
6	I'm not the type to do well in mathematics.	2.91	0.70	High
7	I am proud of my abilities in mathematics when aided with cloud services.	2.92	1.12	High
8	I have a mathematical mind which is enhanced with the aid of cloud services.	2.71	1.05	High
9	I find mathematics confusing even with the aid cloud services.	2.41	0.86	Low
10	Most subjects I can handle OK, but I only manage to endure mathematics even with cloud services.	3.03	0.92	High
11	I know I can do well in mathematics by using cloud services.	2.85	1.21	High
12	I know cloud services are important but I don't feel I need to use them to learn mathematics.	2.48	0.81	Low
13	I can get good grades in mathematics with the aid of cloud services.	2.88	0.97	High
	Cluster Mean	**2.85**		**High**

In Table 1, the result shows that there is a high level of impact of cloud services on the mathematics confidence of mathematics education students in public universities in Benue State, considering the high cluster mean of 2.85 for the sub-scale, as compared to the benchmark of 2.50.

4.1.4 Research question four

To what extent do cloud services affect the affective engagement of mathematics education students in public universities in Benue State?

TABLE 2: Mean Attitude Scores of Affective Engagement of Mathematics Education Students in Public Universities in Benue State

S/No.	Items	Mean	SD	Remark
1	I like using cloud services for mathematics.	2.54	1.13	High
2	In using cloud services to study mathematics, you get your answers correct as rewards for your efforts.	2.79	1.01	High
3	Cloud services aid my interest in learning new things in mathematics.	3.05	0.97	High
4	I find many mathematics problems interesting and challenging with the aid of cloud services.	3.06	0.72	High
5	Learning mathematics through cloud services is enjoyable.	3.01	1.05	High
6	I get a sense of satisfaction when I solve mathematics problems with the aid of cloud services.	2.58	0.71	High
7	I feel good about using cloud services to study mathematics.	2.92	1.13	High
8	Mathematics is more interesting when using cloud services.	2.77	1.00	High
9	I have never been excited about mathematics even with cloud services.	2.94	0.82	High
10	I like the idea of exploring mathematical methods using cloud services.	2.61	1.18	High
11	I always look forward to using cloud services to study mathematics.	2.82	1.15	High
	Cluster Mean	**2.87**		**High**

The results in Table 2 indicate that the affective engagement of mathematics education students in public universities in Benue State is highly impacted by the utilization of cloud services. This was established by the cluster mean attitude score of 2.87 for the affective engagement sub-scale, which is higher than the benchmark of 2.50.

4.1.5 Research question five

To what extent do cloud services affect the behavioural engagement of mathematics education students in public universities in Benue State?

TABLE 3: Mean Attitude Scores of Behavioural Engagement of Mathematics Education Students in Public Universities in Benue State

S/No.	Items	Mean	SD	Remark
1	If I can't solve a mathematical problem, I use cloud services to try out different ideas on how to solve the problem.	2.73	1.15	High
2	I always try to do assignments with the help of cloud services.	3.21	0.92	High
3	Cloud services make me versatile in mathematics.	2.75	0.95	High
4	When studying mathematics using cloud services, I often think of new ways of solving mathematics problem.	2.80	1.01	High
5	I think using cloud services waste too much time in the learning of mathematics.	3.03	1.18	High
6	When learning mathematics with the aid of cloud services, I try to understand new concepts by relating them to things I already know.	2.80	1.02	High
7	Using cloud services to study mathematics makes it easier for me to do more real life applications.	3.16	1.05	High
8	When I cannot understand something in mathematics, I always use cloud services to search for more information to clarify the problem.	2.65	0.83	High
9	Having cloud services to do routine work makes me more likely to try different methods and approaches.	3.14	0.92	High
10	Using cloud services in mathematics is worth the extra effort.	2.86	0.99	High
11	When I study for a mathematics test using cloud services, I try to work out the most important parts to learn.	2.87	0.84	High
12	I prefer to study mathematics by myself, without using cloud services.	2.66	1.17	High
13	When I study mathematics using cloud services, I try to figure out which concepts I still have not understood properly.	3.34	0.89	High
14	If I have trouble in understanding a mathematics problem, I go over it again using cloud services until I understand it.	2.74	1.14	High
15	When I study mathematics with the aid of cloud services, I start by working out exactly what I need to learn.	2.04	0.94	Low
16	I find reviewing previously solved problems using cloud services to be a good way to study mathematics.	3.27	1.02	High
	Cluster Mean	**2.92**		**High**

The results shown in Table 3 indicate a cluster mean attitude score of 2.92 for the behavioural engagement sub-scale which is higher than the benchmark of 2.50. This implies that cloud services highly affect the behavioural engagement of mathematics education students in public universities in Benue State.

4.1.6 Research question six

Which gender's attitude towards mathematics was more affected due to cloud services among mathematics education students in the public universities in Benue State?

TABLE 4: Mean Attitude Score of Male and Female Mathematics Education Students in Public Universities due to the Use of Cloud Services

Gender	N	Mean Attitude Score	Remarks
Male	202	2.782	High
Female	126	2.956	High
Mean Difference		0.174	
Total	328		

Results in Table 4 shows that the mean attitude score of male mathematics education students is 2.782 while that of female mathematics education students is 2.956. Although both male and female mathematics education students scored reasonably high across the CSMAS, a mean difference of 0.174 in favour of female mathematics education students was observed.

4.1.7 Research hypothesis one

There is no significant difference in the mean response of mathematics education students on how cloud services affected students' attitude towards mathematics education in the public universities in Benue State.

TABLE 5: t-Test Analysis of Mean Attitude Scores of Mathematics Education Students from the Two Public Universities

Public University	Mean	N	df	t-calculated	p-value
University of Agriculture Makurdi (UAM)	2.822	246			
			326	5.629	0.000*
Benue State University (BSU)	3.025	82			
Total		328			

*significant at $\alpha = 0.05$

Table 5 shows that the p-value of 0.000 affirms that there is a significant difference in the mean response of respondents on how cloud services affected students' attitude towards mathematics education in the public universities in Benue State, hence the null hypothesis is rejected at 0.05 level of significance. Eyeballing the cluster mean attitude scores of both educational institutions indicate that mathematics education students from Benue State University (BSU) Makurdi are more impacted by cloud services than their counterparts from the University of Agriculture, Makurdi.

4.1.8 Research hypothesis two

There is no significant difference in the mean response of mathematics education students on how cloud services affected male and female students' attitudes towards mathematics education.

TABLE 6: t-Test Analysis of Mean Attitude Scores of Male and Female Mathematics Education Students

Gender	Mean	N	DF	t-calculated	p-value
Male	2.782	202			
			326	2.893	0.004*
Female	2.956	126			
Total		328			

*significant at $\alpha = 0.05$

From the results in Table 6, the p-value of 0.004 which is less than 0.05 indicates that there is a significant difference in the mean response of respondents on how cloud services affected male and female students' attitudes towards mathematics education. The null hypothesis was therefore rejected at 0.05 level of significance.

4.2 Summary of Findings

Based on the analysis of the data from this study, the major findings are:

i. The computer devices readily available among mathematics education students in public universities in Benue State for accessing cloud services are smartphones, tablets and laptops.

ii. Mathematics education students in public universities in Benue State frequently use cloud services.

iii. There is a positive high level of impact of cloud services on the mathematics confidence of mathematics education students in public universities in Benue State.

iv. There is a positive high level of impact of cloud services on the affective engagement of mathematics education students in public universities in Benue State.

v. There is a positive high level of impact of cloud services on the behavioural engagement of mathematics education students in public universities in Benue State.

vi. Although both male and female mathematics education students scored reasonably high across the CSMAS, a mean difference of 0.174 in favour of female mathematics education students was observed.

vii. Mathematics education students from the state government owned Benue State University (BSU) are more positively impacted by cloud services than their

counterparts from the federal government owned University of Agriculture Makurdi (UAM).

4.3 Discussion of Findings

The findings of this study are discussed under the following sub-headings:

i. Computer Devices Readily Available among Mathematics Education Students for Accessing Cloud Services
ii. Frequency of Usage of Cloud Services among Mathematics Education Students
iii. Impact of Cloud Services on Mathematics Confidence of Mathematics Education Students
iv. Impact of Cloud Services on Affective Engagement of Mathematics Education Students
v. Impact of Cloud Services on Behavioural Engagement of Mathematics Education Students
vi. Gender and Impact of Cloud Services on Students' Attitude towards Mathematics Education
vii. Disparity in Level of Technological Integration among Nigerian Public Universities

4.3.1 Computer devices readily available among mathematics education students for accessing cloud services

The results displayed in the pie chart in figure 5 indicated that mathematics education students often access online cloud services using smartphones (49 %), tablets (24 %), laptops (16 %) and mobile phones (8 %). The high percentage of students using smartphones and tablets to access educational cloud services is a pointer to the changing technological landscape which is rapidly enabling the ability to learn on-the-go. This is as established by a

related study by Anyor and Abah (2014) who maintained that a great number of students (70%) deploy smartphones for mobile learning. Smartphones are distinguishable from the less powerful mobile phones in their high specification in terms of 3G to 4G network access, Wi-Fi, Frontal VGA camera, QWERTY keyboard, and compatibility with a wide range of applications such as Microsoft Office, email, PDF readers, and digital encyclopedia. The data in figure 5 agrees with the Device Usability Aspect of educational technological integration put forward by Kenny, Park, Van Neste-Kenny, Burton and Meiers (2009). Most educational content accessible in the cloud are designed for physical, technical and functional components of devices which provides more psychological comfort for users.

4.3.2 Frequency of usage of cloud services among mathematics education students

One of the outcomes of this study as presented in the pie chart in figure 6 is the high frequency of usage of cloud services by mathematics education students. Due to great ease of use, students are increasingly depending on cloud sourced educational contents. This finding agrees with Bavelier, Green and Dye (2010) who rightly observed that high frequency of technology utilization in education is becoming pervasive. This high frequency of usage of cloud services, according to Mills (2014), strengthens specific cognitive strategies in young adults.

4.3.3 Impact of cloud services on mathematics confidence of mathematics education students

The results displayed in Table 1 suggest that cloud service utilization among mathematics education students exerts a high level of impact on the mathematics confidence of the students. This finding implies cloud service adoption is helping mathematics education students overcome their psychological barriers in doing well in mathematics. Cloud services thus enhance the students' natural aptitude in mathematics and raise their belief in their capability to achieve a successful outcome. The high extent of impact of cloud services on the

students' mathematics confidence observed in this study is in agreement with the research findings of Abd-Wahid and Shahrill (2014) and the assertion by Rusinov (2012) that review of good class notes using cloud-sourced contents boosts self-confidence in mathematics. Cloud services avails students the opportunity to utilize free interactive platforms on the Internet, assuring them of their ability to handle difficulties in mathematics. This practice of studying mathematics with online helps develop students' mentality towards mathematics education and improves their self-worth, not only in the discipline, but in life as a whole.

4.3.4 Impact of cloud services on affective engagement of mathematics education students

As reported in Table 2, mathematics education students' affective engagement is highly impacted by the adoption of cloud services (cluster mean = 2.87). This is an indication that the students react well to cloud services utilization as an external incentive to develop personal interest and enjoyment of mathematics. This outcome is in line with the results presented by Barkatsas, Kasimatis and Gialamas (2009) who affirmed that specific technology use in mathematics education is associated with strongly positive levels of affective engagement. Augmentation of mathematics education with cloud services therefore leads to a relatively stable orientation that affects the intensity and continuity of engagement in learning situations, the selection of strategies and the depth of understanding. The observations of this present study has illuminated the fact echoed by Attard and Curry (2012) that cloud services in particular, and technology integration in general, affects how students react to schooling, teachers and peers, influencing their willingness to become involved in school work. This also agrees with Dix (1999) who upheld that the use of computer-based technology in mathematics does appear to positively influence student motivation.

4.3.5 Impact of cloud services on behavioural engagement of mathematics education students

This study has revealed that cloud services positively affect mathematics education students' disposition to manage their own learning by choosing appropriate learning goals and selecting learning strategies appropriate for mathematical tasks. The results displayed in Table 3 indicate that cloud services utilization engenders high level (cluster mean = 2.92) of behavioural engagement among mathematics education students in public universities in Benue State. This is in agreement with Fredricks and McColskey (2012) who observed that behavioural engagement draws on the idea of participation and involvement in learning processes and is considered crucial for achieving positive academic outcomes. The finding of this study reveals that adoption of educational cloud services by mathematics education students yields high impact on the students behavioural engagement as expressed in dimensions outlined in Abd-Wahid and Shahril (2014) such as attentiveness, diligence, time spent on task and non-assigned time spent on task. Cloud services enable mathematics education students to put in a great deal of practice to perfect their mathematical skills which in turn translate to positive attitude towards their field of study. This outcome from this study also agrees with the work of Shechtman, Cheng, Lundh and Trinidad (2012) who emphasized that a fine blend of technology in mathematics instruction delivery raises the level of commitment of learners. Cloud services, as observed in this present study, encourage mathematics education students to develop sound study strategies and try various approaches and methods of solving mathematical problems.

4.3.6 Gender and impact of cloud services on students' attitude towards mathematics education

The analysis of results presented in Table 4 adds commensurately to the debate on repeated priming of mathematics as negatively stereotyped on certain gender of students. The

Mean Attitude Score for female mathematics education students is higher than that of their male counterpart, though both gender display strong positive attitudes towards mathematics education. The weight of this difference in attitude towards mathematics education was further subjected to rigorous hypothesis testing as shown in Table 6. The t-test analysis established a statistically significant difference in the impact of cloud services on students' attitude towards mathematics education between male and female mathematics education students in public universities in Benue State. The implication of these results is that female students tend to better perceive their ability to study mathematics education than male students, particularly with cloud services as means of instructional augmentation. This study which agrees with the works of Wong and Hanafi (2007) and Sanders (2006) reveals that female students are more responsive to technological innovation in mathematics education than their male counterparts.

This outcome is obviously in conflict with several traditional studies which upheld mathematics as a male-dominated field of study. In this vein, this finding is in sharp contrast to Fatade *et al.* (2012) who maintain that males tend to show a natural positive attitude to school mathematics while females display negative attitude. Ursini and Sanchez (2008) in a longitudinal comparative study also found significant gender difference in attitudinal change favouring boys when students are subjected to technology augmented mathematics education. Similarly, Pierce *et al.* (2007) reveal that boys have higher scores than girls for each sub-scale of their newly developed MTAS. Keen observation and scrutiny of the body of evidence in favour of the male gender reveals that unlike the present study, most of these studies are based on subjects at the early childhood and lower levels of education where gender disparities are predominant.

However, on the other side of the gender debate to which the findings of this study has lent weight, are a series of deeper psychological enquiries such as the one by Spelke

(2005) who concluded that highly talented male and female students show equal abilities to learn mathematics. This finding also supports the results of Olibe *et al.* (2014) who reported that female students have more knowledge of virtual learning than male students. Lindberg *et al.* (2010) relatedly held that due to cultural shifts initiated by increasing levels of technology penetration in recent years, the gender gap is closing. Towing a similar path, Adebule and Aborisade (2014) recommended that sex should not be considered as a factor influencing attitude of students towards mathematics and that teachers should teach mathematics freely among all categories of learners.

The higher rate of impact of cloud services among female mathematics education students observed in this study could be a pointer to a new demographical structure of technology adoption. Female students who are at the receiving end of the gender complex are now gradually looking up to available means of supporting their mathematics learning. With time, the need to look out for gender disparity in mathematics education may disappear altogether. This line of reasoning has also been suggested by Bergeron (2011) who observed that women are most likely to adopt new technology when it is social, relevant, and seamlessly improves their day-to-day efforts as obtained in mathematics education.

4.3.7 Disparity in level of technological integration among Nigerian public universities

A comparison of the extent of impact of cloud services on students' attitudes towards mathematics education between public universities in Benue State turned out in favour of Benue State University (BSU) Makurdi. The results presented in Table 5 indicate the Mean Attitude Score of mathematics education students in BSU as 3.025 against that of UAM which is 2.822. The implication of this outcome is that mathematics education students from BSU, a State Government owned university, are more impacted by the utilization of cloud services than their counterparts from the Federal Government owned UAM. This difference unveils several complex underlying issues bordering on service delivery by the ICT

directorates of the educational institutions. This finding agrees with the earlier reported work of Oyeleye *et al.* (2014) who found only 10 % efficiency in adoption of cloud computing by public universities in Nigeria. Most of the efficient cloud services delivery systems reported in available literature such as that by Adeyeye *et al.* (2014) are predominantly hosted by private universities.

This finding has suggested that the State University offers better cloud-based services, particularly in terms of infrastructure as a service (IaaS) available unto students, as evidenced in the level of impact on mathematics education students' attitudes. Technical factors such as distribution of wireless access points within a campus, power supply to access points, bandwidth and strength of broadband, and maintenance of service equipment by staff of the ICT directorate, determine the quality of service students get.

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter deals with the summary of the study, conclusion based on the study, recommendations, limitations of the study and suggestions for further studies.

5.1 Summary

This study focused on the impact of cloud services on students' attitude toward mathematics education in public universities in Benue State, Nigeria. The study employed an ex post facto research design to administer the Cloud Service Impact Questionnaire (CSIQ) to a proportionate sample of 328 mathematics education students drawn from the two public universities in Benue State with functional cloud service delivery system, namely, Benue State University (BSU) Makurdi and University of Agriculture Makurdi (UAM).

Simple percentages, pie charts, means and standard deviation were used to answer the research questions while the student's t-test was used to test the stated hypotheses at 0.05 level of significance. Analysis of collected data shows that mobile devices such as smartphones, tablets, and laptops are readily available among mathematics education students for accessing cloud services. It was also found that there is a high frequency of usage of cloud services among mathematics education students in public universities in Benue State.

Analysis of results obtained from the Cloud Services showed that Mathematics Attitude Scale (CSMAS), a section of the CSIQ, revealed that cloud services exert high impact on the mathematics confidence, affective engagement and behavioural engagement of mathematics education students in public universities in Benue State. Surprisingly, the results also indicated a high level of impact of cloud services on attitude towards mathematics education among female students than their male counterparts. A test of hypothesis established that this observed difference was significant.

Relatedly, the study recorded a significant disparity in the impact of cloud services on mathematics education students' attitude towards their discipline between the two public universities used for this work. Benue State University (BSU) Makurdi performed better on the summated attitude scale than University of Agriculture Makurdi (UAM). This disparity could among other things be due to the level of efficiency of cloud service delivery in the State Government owned and Federal Government owned higher educational institution.

5.2 Conclusion

Insights into students' attitudes and beliefs are the most important and crucial steps in understanding how the learning environment for mathematics education is affected by the introduction of digital technology. The private cloud services delivered by public universities in Benue State have been increasingly influencing the way mathematics education students study and do research, thereby altering their views, perspectives and disposition towards their discipline.

This study has specifically established a substantial impact of the utilization of cloud services on students' attitude toward mathematics education in the attitudinal component areas of mathematics confidence, affective engagement and behavioural engagement. Cloud services adoption results in strong positive mentality and self-worth among mathematics education students. It also leads to students feeling good, thinking hard and actively participating in their own mathematics learning.

Obviously, allowing students' choice in the mathematics education process is an important element of engagement and sends important messages relating to power and control. The choice of cloud services by mathematics education students as a sort of technological augmentation has opened up rich avenues to develop highly engaging, student-centred mathematical activities and tasks. Engagement in mathematics occurs when students are procedurally engaged during the course of learning and beyond, as they enjoy learning

and doing mathematics, and they view beyond the classroom. These outcomes have been revealed to be positively impacted by the utilization of cloud services by mathematics education students in public universities in Benue State, Nigeria.

5.3 Recommendations

The following recommendations are made based on the findings of this study:

i. Students of mathematics education should seek deeper and more enriched learning experience by continuously leveraging on available cloud services, benefiting from several online mathematical communities and developing themselves in life-sustaining skills.

ii. Mathematics educators should incorporate emergent technologies like the educational cloud in their instructional design to flexibly support the teaching and learning process and improve students. More instructional aids can be cued from the World Wide Web (WWW) via educational institution-hosted cloud services for all round pedagogical development.

iii. The ICT directorates of public universities should wake up to the challenge of epileptic service delivery by building a consistent maintenance culture to sustain efficient cloud service delivery system. More access points should be made available everywhere on campus, even around students hostels, to support efficient mobile learning.

iv. The management of public universities in Benue State in particular, and Nigeria in general, should make a concerted effort targeted at improving the deployment of technological infrastructure in their institutions. The commitment on the part of schools’ management can only translate to flexible ways of doing things and effective approaches to teaching and learning by faculties and students.

v. The federal and state governments must make more funds available to public universities for technological development and state-of-the-art service delivery. Only a sustained sponsorship from the government can improve the status of Nigerian universities in global ranking.

5.4 Limitations of the Study

This study, despite its robustness, was constrained by the influence of the unstable nature of the cloud network in the two public universities in Benue State. This was due to the epileptic power supply to some access points delivering cloud network IaaS. Respondents also complained about fluctuations in up-link and down-link rate on the network due to over-crowding.

5.5 Suggestions for Further Studies

Based on the obvious limitations of this study, the following suggestions are proposed for further studies.

i. Any deeper consideration of the effect of cloud services on students' actual learning should involve an on-the-spot measurement via quasi-experiment in a blended instructional framework. This may entail collaborations with the institutions management to provide uninterrupted broadband access.

ii. Future studies may seek to enlarge the scope of this present study to encompass a wider geographical reach and other related psychological constructs.

REFERENCES

Abd Wahid, N. & Shahrill, M. (2014). Pre-university students' engagement towards the learning of mathematics. *Proceeding of the Social Sciences Research ICSSR*, 379-388.

Abedalaziz, N., Jamaluddin, S. & Leng, C. H. (2013). Measuring attitude toward computer and internet usage among post graduate students in Malaysia. *The Turkish Online Journal of Educational Technology, 12(2)*, 2000-2016

Achor, E. E. & Tyavbee, A. J. (2014). Understanding of usefulness of mathematics, perceptions on teacher's attitudes and mathematics as a male domain as predictors of students' confidence in mathematics. *Benue State University Journal of Education (BSUJE), 14*, 37-45.

Adebule, S. O. & Aborisade, O. J. (2014). Gender comparison of attitude of senior secondary school students toward mathematics in Ekiti State, Nigeria. *European Scientific Journal, 10(9),* 153-160.

Adeyeye, O. M., Afolabi, I. T. & Ayo, C. K. (2014). Virtual learning in Nigerian universities: A panacea for enhanced academic standards. *International Journal for Innovation Education and Research, 2(2),* 40-49.

Ajzen, I. (1988). *Attitudes, personality, and behavior*. Milton-Keynes, England: Open University Press & Chicago, IL: Dorsey Press. p 15.

Alexonponlou, E. (1997). Gender differences in small group discussion in physics. *International Journal of Science Education, 19,* 393-406.

Anderson, R. A. & Pearson, P. D. (1984). A schema-theoretic view of basic processes in reading comprehension. In P. D. Pearson (Ed.), *Handbook of Reading Research.* New York: Longmans. pp 225-292

Antonio C. (2008). *On the importance of mathematics.* Retrieved on 18th September, 2012 from http://math-blog.com/2008/13/31/ on- the – importance – of – mathematics/

Anyor, J. W. & Abah, J. A. (2014). Students' perception of mobile learning in a blended collaborative learning framework in mathematics. *Benue Journal of Mathematics and Mathematics Education,* 1(3), 20-27

Arenyeka, L. (2014). Is talk cheap?: Nigerians spend N447.8bn on recharge cards monthly. *Vanguard News.* Retrieved on 29th March, 2014 from http://www.vanguardngr.com/2014/03/talk-cheap-nigerians-spend-n447-8bn-recharge-cards-monthly/

Arigbabu, A. A. & Mji, A. (2004). Is gender a factor in mathematics performance among pre-service teachers? *Sex Roles, 51,* 749-753.

Artigue, M. (2012). *The Challenges of Change in Teaching Practice.* UNESCO: Paris

Atherton, J. S. (2011). *Learning and teaching: Piaget's developmental theory*. Retrieved on 7th June, 2015, from http://www.learningandteaching.info/learning/piaget.htm

Atkinson, R. C., & Shiffrin, R. M. (1968) Human memory: A proposed system and its control process. In K. W. Spence (Ed.), *The Psychology of Learning and Motivation: Advances in Research and Theory, 2,* 89-125. New York: Academic Press.

Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *Australian Primary Mathematics Classroom- APMC, Professional Journal of the Australian Association of Mathematics Teachers Inc.,* 17(1), 9-13.

Attard, C. & Curry, C. (2012). Exploring the use of iPad to engage young students with mathematics. In J. Dindyal, L. P. Cheng & S. F. Ng (Eds.) *Mathematics education: Expanding horizons*. Proceedings of the 35th Annual Conference of the Mathematics Research Group of Australasia. Singapore: MERGA

Awofala, A. O. A. (2011). Is gender a factor in mathematics performance among senior secondary school students with varying school organization and location? *International Journal of Mathematics Trends and Technology, 2,* 17-21.

Axelrod, R. (1973). Schema theory: An information processing model of perception and cognition. *The American Political Science Review, 67(4),* 1248-1266

Ayeni, M. A. & Dada, M. A. (2011). An exploration into the education innovations in Nigeria in the last two decades. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS)* , 2(4), 199-205

Baez, G., Kechiche, B. & Boguszewska, S. (2010). *The impact of mobile services in Nigeria: How mobile technologies are transforming economic and social activities.* Cambridge, MA: Pyramid Research. 3-145

Bakardjieva, T. (2014). *Introduction to computer networking.* Varna: Institute of Technology-Varna Free University. 1-22

Baron-Cohen, S. (2003). The essential difference. The truth about the male and female brain. New York: Basic Books. p 21.

Barkatsas, A. (2004). *A new scale for monitoring students attitude for learning mathematics with technology*. Melbourne: St. Joseph's College. pp 1-8.

Barkatsas, A. N., Kasimatis, K. & Gialamas, V. (2009). Learning secondary mathematics with technology: Exploring the complex interrelationship between students attitudes, engagement, gender and achievement. *Computer & Education*, 52(3), 562-570. DOI: 10.1016/j.compedu.2008.11.001

Bavelier, D., Green, C. S. S. & Dye, M.W.G. (2010).Children, wired: For better and for worse. *Neuron*, 67, 692-701

Benue State Government (2015). *Historical Background*. Retrieved on 7th June, 2015, from http://www.benuestate.gov.ng/wp/about_us/historical-background/

Berge, Z. (2002). Active, interactive, and reflective eLearning. *Quarterly Review of Distance Education, 3(2),* 181-190.

Bergeron, J. (2011). Digital and very social American women and technology adoption. Retrieved on 29th April, 2016 from http://www.nielsen.com/us/en/insights/news/2011/digital-and-very-social-american-women-and-technology-adoption.html

Best, M. L. (2003). The wireless revolution and universal access. *Trends in Telecommunications Reform, 1-24.*

Binder, M. & Niederle, U. (2007). *Institutions as determinants of preference change: A one way relation?* Retrieved on 11th June, 2015, from https://papers.econ.mpg.de/evo/discussionpapers/2006-07.pdf

Bucci, T. T., Copenhaver, L. J., Lehman, B. & O'Brien, T. (2003). Technology integration: Connections to educational theories. *Contemporary Issues in Technology and Teacher Education, 3(1),* 26-42

Carr, A. M. & Carr, C. S. (2000). *The Nine events of instruction.* Retrieved on 7th June, 2015, from http://ide.ed.psu.edu/idde/9events.htm

Cassady, L. (2014). *What are the primary purposes of education?* Retrieved on 18th March, 2014 from http://www.ehow.com/m/info_8192984_primary_purpose_education.html

Chamberlin, S. A. (2010). A review of instruments created to assess affect in mathematics. *Journal of Mathematics Education,* 3(1), 167-182.

Chapman, E. (2003). Development and validation of a brief mathematics attitude scale for primary-aged students. *Journal of Educational Enquiry, 4(2), 63-73.*

Churcher, K. M. A., Downs, E. & Tewksbury, D. (2014). "Friending" Vygotsky: A social constructivist pedagogy of knowledge building through classroom social media use. *The Journal of Effective Teaching, 14(1),* 33-50

Cloud Security Alliance (2009). *Security Guidance for Critical Areas of Focus in Cloud Computing V2.1.* Retrieved on 16th September, 2012 from http://www.cloudsecurityalliance.org/guidance/csaguide.V2.1.pdf

Craig, D. J. (2009). *Defining a 21st century education.* Alexandria, VA: The Centre for Public Education, 1-79.

Dix, K. (1999). Enhanced mathematics learning: Does technology make a difference? *Mathematics Education Group of Australia - MERGA, 22,* 192-199.

Doepken, D., Lawsky, E. & Padwa, L. (1993). *Modified Fennema-Sherman Attitude Scales.* Paper presented at the Woodrow Wilson Gender Equity in Mathematics and Science Congress, Princeton, in June, 1993. Retrieved on 19th February, 2015, from http://www.stuckonscience.org/StuckonScience/Teachers_Only/Entries/2014/3/19_Fixed_vs._Growth_Mindset_Awareness_comes_First!_(Part_1)_files?Math%20Attitude%20Self%20Survey.doc

Doerr, A. (2011). *Gender issues in math education.* Retrieved on 21st February, 2015, from http://www.unr.edu/Documents/education/math-camp/doerr-gender-math-paper.doc

Doolittle, P. E. & Hicks, D. (2003). *Constructivism as a theoretical foundation for the use of technology in social studies.* Blacksburg, VA: Virginia Tech. pp 1-31

Dudley, U. (2010). What is mathematics for? *Notices of the AMS, 57(5), 6028-613.*

Eccles, J. S. & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 153,* 109-132

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M. & Meece, J. L. (1983). Expectancies, values and academic behaviors. In J. T. Spencer (Ed.), *Achievement and Achievement Motives.* San Francisco: Freeman. pp 75-146

Edukugho, E. (2012). *Challenge of Producing Unemployable Graduates.* Retrieved on 23rd July, 2012 from http://www.vanguard/ngr.com/2012/07/challenge - of - producing – unemployable – graduates/

Emaikwu, S. O. (2011). Fundamentals of research methods and statistics. Makurdi: Selfers Academic Press. p 29.

Ernest, P. (2014). *What is the philosophy of mathematics education?* Retrieved from http://people.exeter.ac.uk/PErnest/Pome18?PhoM_%20for_ICME_04.htm

Fatade, A. O., Nneji, L. M., Awofala, A. O. A. & Awofala, A. A. (2012). Mode of entry and gender as determinants of Nigerian pre-service teachers' performance in degree mathematics and science courses. *International Journal of Mathematics Trends and Technology, 3(3),* 103-109.

Feather, N. T. (1988). Values, valences, and course enrollment: Testing the role of personal values within an expectancy-value framework. *Journal of Educational Psychology, 80,* 381-391

Fennema, E. & Sherman, J. A. (1976) Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education, 7(5),* 324-326.

Fogarty, G. J., Cretchley, P., Harman, C., Ellerton, N. & Konki, N. (2001). Validation of a Questionnaire to Measure Mathematics Confidence, Computer Confidence, and Attitudes of the Use of Technology for Learning Mathematics. *Mathematics Education Research Journal,* 13(2), 154-160. ISSN 1033-2170.

Frazier-Kouassi, S. (1999). A psychological study of mathematics attitudes and achievement among female Ivorian students. Working Paper #268, Institute for Social Research, University of Michigan, pp 1-18.

Fredricks, J. A. & McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In S. L. Christenson (Ed.) *Handbook of Research on Student Engagement,* 763-782.

Galbraith, P. & Haines, C. (1998). Disentangling the nexus: Attitude to mathematics and technology in a computer learning environment. *Educational Studies in mathematics, 36*, 275-290.

Gillani, B. B. (2003). *Learning theories and the design of e-learning environments.* Lutham, Maryland: American University Press.

Gillani, B. B. (2013). *Cognitive theory and the design of education to work connection.* Hayward, CA: California State University. pp 1-6

Gomez-Chacon, I. M. & Haines, C. (2008). *Students' attitudes to mathematics and technology: A comparative study between the United Kingdom and Spain.* 11th International Congress on Mathematics Education - ICME-11.

Goodykoontz, E. (2009). *Factors that affect college students' attitude toward mathematics*. Retrieved on 27th January, 2015, from https://mathed.asu.edu/crume2009/goodykoontz_long.pdf

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S. & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8,* 1-51.

Harms, R. & Yamartino, M. (2010). *The economics of the cloud.* Microsoft, pp 1-21.

Hildago, S., Maroto, A. & Palacios, A. (2005). El perfil emocional matematico como predictor de rechazo escolar: Relacion con las destrezas y los conocimientos desde una perspectiva evolutiva. *Revisita de Educacion matematica, 17(2),* 89-116.

Hulleman, C. S. & Harackiewicz, J. M. (2009). Promoting interest and performance in high school science classes. *Science, 328(5958),* 1410-1412

Hung, D. (2001). Theories of learning and computer-mediated instructional technologies. *Emergency Management Institute - EMI Online Learning Design, 38(4),* 281-287. ISSN: 1469-5790 DOI: 10.1080/09523980110105114. Retrieved from http://www.tandf.co.uk/journals

Hurwitz, J., Bloor, R., Kaufman, M. & Halper, F. (2010). *Cloud computing for dummies.* Hoboken, NJ: Wiley Publishung Inc.

Ibaishwa, R. L. (2014). Shyness and emotional intelligence as predictors of mathematics anxiety among secondary school students in Makurdi, Benue State. *Journal of Educational Policy and Entrepreneurial Research (JEPER), 1(2)*, 11-21.

Ifenkwe, G. E. (2013). Educational development in Nigeria: Challenges and prospects in the 21st century. *Universal Journal of Education and General Studies, 2(1),* 7-14.

Iji, C. O., Abah, J. A. & Uka, N. K. (2013). Attaining the Millenium Development Goals (MDGs) through Effective Mathematics Education. *Proceedings of the 54th Annual Conference of Science Teachers Association of Nigeria,* 99-107.

Innovation Unit (2014). *21st century learning.* Retrieved on 18th March, 2014 from http://www.innovationunit.org/knowledge/our-ideas/21st-century-learning

Italiano, E. (2014). *Community, contemplation, and computers: The role of technology in education.* Retrieved on 18th March, 2014 from http://www.thepublicdiscourse.com/2014/02/11789/

Johnson, L. N. A. & Hiran, K. K. (2014). *Cloud computing in Ghanian Higher Educational Institutions*. A paper presented at the International Conference on Science, Technology, Education, Arts, Management and Social Sciences (iSTEAMS), held at Afe Babalola University, Ado-Ekiti, Nigeria, in May 2014. pp 225-230.

Jones, M. G. & Brader-Araje, L. (2002). The impact of constructivism on education: Language, discourse, and meaning. *American Communication journal, 5(3)*

Joubish, M. F. & Khurram, M. A. (2011). Cognitive development in Jean Piaget's work and its implications for teachers. *World Applied Sciences Journal, 12(8),* 1260-1265

Kaino, L. M. (2009). Undergraduates' attitudes and the study of mathematics at the University of Swaziland. A paper presented to the Association of African Universities, Accra – Ghana in September, 2009. Pp 1-36.

Kandarakis, A. G. & Poulos, M. S. (2008). Teaching implications of information processing theory and evaluation approach of learning strategies using LVQ neural network. *Advances in Engineering Education, 5(3),* 111-119

Katz, R., Goldstein, P. & Yanosky, R. (2009). *Cloud computing in higher education.* EDUCAUSE. Retrieved on 5th April, 2013 from http://net.educause.edu/section_params/conf/CCW10/highered.pdf

Kenny, R. F., Park, C., Van Neste-Kenny, J. M. C., Burton, P. A. & Meiers, J. (2009). Using mobile learning to enhance the quality of nursing practice education. In M. Ally (Ed.) *Mobile Learning: Transforming the Delivery of Education and Training.* Edmonton: AU Press. pp 75-98

Kilpatrick, J. & Findell, B (2001). *Adding it up: Helping children learn mathematics*. Washinton, D. C. National Academy Press

Kilpatrick, J. (2008). *The development of mathematics education as an academic field*. A paper prepared for Plenary Lecture 1 at the Symposium on the occasion of the 100th Anniversary of ICMI held in Rome, 5th-8th March, 2008. pp 1-18.

Kovachev, D., Cao, Y. & Klamma, R. (2011). *Mobile cloud computing: A comparison of application models*. Aachen: RWTH Aachen University, pp 1-8.

Kumari, M. & Singh, V. (2009). *Mobile learning: An emerging trend.* Bombay: Tata Consultancy Services Limited. 1-9.

Lafortune, L., Daniel, M. F., Fallacio, R. & Schleider, M. (2000). Evolution of pupils' attitudes to mathematics when using a philosophical approach. *Analytic Teaching and Philosophical Praxis, 20(1), 46-63.*

Larsen, J. (2013). *Attitude in mathematics: A thematic Literature Review*. British Columbia : Simon Fraser University. pp 1-10.

Larson, M. (2002). *Essential characteristics of effective mathematics instruction.* Lincoln: Houghton Mifflin Company, pp 1-4.

Lindberg, S. M., Hyde, J. S. & Petersen, J. L. (2010) New trends in gender and mathematics performance: A meta-analysis. *Psychology Bulletin, 136(6)*, 1123-1135. DOI: 10.1037/a0021276

Lokesh, U. (2013). *Technology and its role in 21st century education.* Retrieved on 18th March, 2014 from http://www.edtechreview.in/trends-insights/insights/277-role-of-technology-in-21st-century

Lutz, S. T. & Huitt, W. G. (2004). Connecting cognitive development and constructivism: Implications from theory for instruction and assessment. *Constructivism in the Human Sciences, 9(1),* 67-90

Lutz, S. & Huitt, W. (2003). Information processing and memory: Theory and applications. *Educational Psychology Interactive.* Valdosta, GA: Valdosta State University. pp 1-17. Retrieved from http://www.edpsyinteractive.org/papers/infoproc.pdf

Mayer, R. E. (2005). Introduction to multimedia learning. In R. E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning.* New York: Cambridge University Press

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In E. D. Grows (Ed.), *Handbook of Research on Mathematics Teaching and Learning*. New York: McMillan Publishing Company. pp 575-596.

Mills, K. L. (2014). Effects of internet use on the adolescent brain: Despite popular claims, experimental evidence remains scarce. *Trends in Cognitive Sciences*, 18(8), 385-387

Mircea, M. & Andreescu, A. I. (2011). Using cloud computing in higher education: A strategy to improve agility in the current financial crisis. *Communications of the International Business Information Management Association - IBIMA, 2011.* Retrieved on 25th February, 2014 from http://www.ibimapublishing.com/journals/CIBIMA/cbima.html DOI:10.5171/2011.875547

Miseviciene, R., Budnikas, G. & Ambraziene, D. (2011). Application of cloud computing at KTU: MS Live @Edu Case. *Informatics in Education, 10(2), 259-270.*

Mohamed, L. & Waheed, H. (2011). Secondary students' attitudes towards mathematics in a selected school of Maldives. *International Journal of Humanities and Social Science,* 1(15), 277-281.

Moja, T. (2010). Nigeria education sector analysis: An analytical synthesis of performance and main issues. A document produced for the World Bank in January, 2000, pp 1-45

Moursund, D. (2014). *What is mathematics?* Retrieved on 11th February, 2015, from http://pages.uoregon.edu/moursund/math/mathematics.htm

Muyinda, P. B., Lubega, J. T. & Lynch, K. (2010). Mobile learning objects deployment and utilization in developing countries. *International Journal of Computing and ICT Research, 4*(1), 37-45.

National Council of Teachers of Mathematics (2009). *Guiding principles for mathematics curriculum and assessment*. Reston, VA: National Council of Teachers of Mathematics. 1-5

National Universities Commission (2012). *Approved/Accredited programmes of Nigerian universities.* Abuja: National Universities Commission. pp 1- 138.

Neto, M. I. A. S. (2004). *Wireless networks for the developing world: The regulation and use of license-exempt radio bands in Africa.* An M.Sc Thesis submitted to the Engineering Systems Division at Massachusetts Institute of Technology. 1-226

New Jersey Mathematics Curriculum Framework (2014). *Planning for change.* Trenton, NJ: New Jersey State Department of Education. 593-666

Niharika, K., Lavanya, G., Murthy, G. V. & Satya Sai Kumar, A. (2012). Educational cloud: Utilization of Iaas versus Paas Services. *International Journal of Scientific & Engineering Research, 3(1).* ISSN 2229-5518. Retrieved on 29th March, 2014 from http://www.ijser.org

Norton, S. J. & Rennie, L. J. (1998). Students' attitudes towards mathematics in single-sex and co-educational schools. *Mathematics Education Research Journal, 10(1),* 16-36.

Nowell, A. & Hedges, L. V. (1998). Trends in gender differences in academic achievement from 1960-1994: An analysis of differences in mean, varian, and extreme scores. *Sex Roles, 39,* 21-43.

O'Brien, T. C. (2002). *The goals of mathematical education.* Retrieved on 14th September, 2015, from http://mathematicallysane.com/goal-of-mathematical-education

Odili, G. O. (2012). Towards a new paradigm of teaching mathematics in Nigerian universities: The role of mathematics educators. *Online Journal of Science Teachers Association of Nigerian (STAN), 47(1).*

Organization for Economic Co-operation and Development -OECD (2004). Learning for tomorrow's world. Retrieved on 20th July, 2015 from http://www.oecd-ilibrary.org/education/learning-for-tomorrow-s-world-9789264006416-en.

Okafor, C. F. & Anaduaka, U. S. (2013). Nigerian school children and mathematics phobia: How the mathematics teacher can help. *American Journal of Educational Research, 1(7), 267-271.* DOI: 10.12691/education-1-7-9

Okai, S., Uddin, M., Arshad, A., Alssaqour, R. & Shah, A. (2014). Cloud computing adoption model for universities to increase ICT proficiency. *SAGE Open,* 1-10. DOI:10.1177/2158244014546461

Okonjo-Iweala, N. (2012). *Reforming Nigeria's education system: Paradigm shift.* A keynote speech at the 2012 Isaac Moghalu Foundation Lecture at Civic Centre, Victoria Island, Lagos, on Thursday, July 12, 2012. Pp 1-17.

Olibie, E. I., Ezoem, M. N. & Ekene, U. S. (2014). Awareness of virtual learning among students of two Nigerian universities: Curriculum, implications. *International Journal of Development and Economic Sustainability, 2(1),* 48-62.

Osafehinti, I. O. (2015). *Mathematics in adult education: The Nigerian experience.* Retrieved on 11th February, 2015, from http://www.alm-online.net/images/ALM/conferences/ALM15/proceedings/ALM15-proceedings-p166-175.pdf

Oyeleye, C. A., Fagbola, T. M. & Daramola, C. Y. (2014). The impact and challenges of cloud computing adoption in public universities in southwestern Nigeria. *International Journal of Advanced Computer Science and Applications, 5(8),*13-19.

Palacios, A., Arias, V. & Arias, B. (2014). Attitudes towards mathematics: Construction and validation of a measurement instrument. *Revista de Psicodidactica, 19(1)*, 67-91.

Partnership for 21st Century Skills (2002). *Learning for the 21st century: A report and mile guide for 21st century skills.* Washington: Partnership for 21st Century Skills, 1-5.

Perry, C. A. (2011). Motivation and attitude of pre-service elementary teachers toward mathematics. *Morehead State University School Science and Mathematics, 111(1)*, 2-10.

Pham, H. (2011). Theory-based instructional models applied in classroom contexts. *Literacy Information and Computer Education Journal, 2(2),* 406-415

Phillips, R., Kennedy, G. S. & McNaught, C. (2012). The role of theory in learning technology evaluation research. *Australasian Journal of Educational Technology, 28(7),* 1103-1118.

Piaget, J. (2001). *The psychology of intelligence (2nd Ed.).* London: Routledge. [originally published in 1950].

Pierce, R., Stacey, K. & Barkatsas, A. (2007). A scale for monitoring students' attitudes to learning mathematics with technology. C*omputers & Educaation, 48, 285-300.*

Powell, J. (2009). *Cloud computing- What is it and what does it mean for education?* Retrieved on 10th September, 2012 from http://erevolution.jiscinvolve.org/wp/files/2009/07/clouds-johnpowell.pdf

Prawat, R. S. & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychology, 29(1),* 37-48

Raja, R. S. (2002). *Education for the twenty-first century: Asia-Pacific Perspective.* Bangkok: UNESCO, 1-111.

Ramirez, C., Emmioglu, E. & Schau, C. (2010). Understanding students' attitudes towards statistics: New perspectives using an Expectancy-Value Model of motivation and Survey of Attitudes Toward Statistics. Paper presented at the Joint Statistical Meetings Vancouver. Pp 1-5

Reed, H. C., Drijvers, P. & Kirschner, P. A. (2009). *Effects of attitudes and behaviours on learning mathematics with computer tools.* Amsterdam: Faculty of Psychology and Education, VU University Amsterdam, 1-54.

Rusinov, A. (2012). *How to boost self-confidence in mathematics.* Retrieved on 28th April, 2016 from http://www.mcny.edu/student_serv/lecblog/how-to-boost-self-confidence-in-mathematics-and-get-ready-for-math-tests

Salman, M. F. (2001). An Investigation into Female Enrolment in Mathematics and Sciences at the University of Ilorin. *Nigerian Journal of Health, Education and Welfare of Special People,* 5(1): 65 – 76.

Salman, M. F., Yahaya, L. A. & Adewara, A. A. (2011). Mathematics education in Nigeria: Gender and spatial dimensions of enrollment. *International Journal of Education and Science, 3*(1), 15-20.

Sanders, J. (2006). Gender and technology in education: A research review. In C. Skelton, B. Francis & L. Smulyan (Eds.) *Handbook of Gender in Education.* London: Sage Publications, 1-50

Santos, S. & Barmby, P. (2010). Enrichment and engagement in mathematics. In M. Joubert & P. Andrews (Eds.), *Proceedings of the British Congress for Mathematics Education,* 199-206.

Saritas, T. & Akdemir, O. (2009). *Identifying factors affecting the mathematics achievement of students for better instructional design.* Retrieved from http://www.itdl.org/Journal/dec_09/article03.htm

Schau, C. (2003). *Students' attitudes: The "other" important outcome in statistics education.* A paper presented at the Joint Statistics Meetings, San Francisco, 1-47.

Sclater, N. (2010). Cloud Computing in Education. Moscow: UNESCO Institute for Technologies in Education. 1-12.

Shechtman, N., Cheng, B. H., Lundh, P. & Trinidad, G. (2012). Unpacking the black box of engagement: Cognitive, behavioural, and affective engagement in learning mathematics. In J. Van Aalst, K. Thompson, M. J. Jacobson & P. Reimann (Eds.) The Future of Learning: Proceedings of the 10th International Conference of the Learning Sciences (ICLS 2012) – Vol. 2, pp 53-56

Singh, R. R. (1991). Education for the twenty-first century: Asia-Pacific perspectives. Bangkok: UNESCO Principal Office for Asia and the Pacific. Pp 1-89.

Sjoberg, S. (2007). Constructivism and Learning. In E. Baker, B. McGaw, & P. Peterson (Eds.), *International Encyclopedia of Education, 3rd Edition.* Oxford: Elsevier

Sorden, S. D. (2012). *The cognitive theory of multimedia learning.* Mohave: Mohave Community College. pp 1-31

Spelke, E. S. (2005). Sex differences in intrinsic aptitude for mathematics and science?: A critical review. *American Psychologist, 60(9),* 950-958. DOI: 10.1037/0003-066X.60.9.950

Steele, J. R. & Ambady, N. (2006). Math is hard: The effect of gender priming on women's attitudes. *Journal of Experimental Social Psychology*, 42, 428-436. DOI: 10.1016/j.jesp.2005.06.003

Steijaert, A., Boyle, B., Leinen, S., Melve, I. & Mitsos, Y. (2012). The Adoption of Cloud Services. ASPIRE. pp 1-37.

Strauss, S. (2000). Theories of cognitive development and their implications for curriculum development and teaching. In B. Moon, M. Ben-Peretz, and S. Browns (Eds.), *Routledge International Companion to Education.* London: Routledge. pp 33-50

Suthers, D. (2014). *Information processing theory of learning.* Pittsburg: Learning Research & Development Centre, University of Pittsburg. pp 1-11. Retrieved on 9th November, 2015, from http://www.pitt.edu/~suthers/

Swan, K. (2005). A constructivist model for thinking about learning online. In J. Bourne & J. C. Moore (Eds.), *Elements of Quality Online Education: Engaging Communities.* Needham, MA: Sloan-C

Tall, D. (2014). *Information technology and mathematics education: Enthusiasm, possibilities and realities.* Coventry: University of Warwick. Pp 1 – 16.

Tapia, M. & Marsh, G. E. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8(2),* 16-21

Tennyson, R. D. (2010). Historical reflection on learning theories and instructional design. *Contemporary Educational Technology, 1(1),* 1-16

Tekerek, M., Yeniterzi, B. & Ercan, O. (2011). Math attitudes of computer education and instructional technology students. *The Turkish Online Journal of Educational Technology – TOJET,* 10(3), 168-174

Thisday (2012). *Benue's Opaque Budget*. An article in Thisday Newspaper. Retrieved on 7th June, 2015, from http://www.thisdaylive.com/articles/benue-s-opaque-budget/114605/

Thomas, P. Y. (2011). Cloud computing: A potential paradigm for practicing the scholarship of teaching and learning. *Electronic Library, 29(2), 214-224.*

UNICOM Government Inc. (2009). *Cloud computing: Building a framework for successful transition.* Herndon, VA: UNICOM Government Inc. pp 1-5.

United Nations Education, Scientific and Cultural Organization - UNESCO (2010). *The Central Role of Education in the Millennium Development Goals.* UNESCO.

United Nations Education, Scientific and Cultural Organization - UNESCO (2012). *Challenges in Basic Mathematics Education.* UNESCO

Ursini, S. & Sanchez, G. (2008). Gender, technology and attitude towards mathematics: A comparative longitudinal study with Mexican students. *ZDM International Journal of Mathematics Education, 40(4)*, 559-577.

Vaquero, L., Merino, L., Caceres, J. & Lindner, M. (2009). A Break in the clouds: Towards a cloud definition. *SIGCOMM Computing Community Revolution, 39(1), 50-55.*

Vygotsky, L. S. (1978). *Mind in Society.* Cambridge: Havard University Press

Wang, M., Brown, F. & Ng, J. W. P. (2011). Current instructional design models and principles for effective e- and mobile learning. *Educational Web of San Diego State University [eJournal].* Retrieved from

http://edweb.sdsu.edu/courses/edtec596/ml/slides/week9/DesignPrinciples_BrownWang.pdf

Wenger, E., White, N. & Smith, J. (2009). Digital habitats: Stewarding technology for communities. CP Square Press.

Whitin, P. E. (2007). The mathematics survey: A tool for assessing attitudes and dispositions. *Teaching Children Mathematics, 426-433.*

Wilson, B. G. & Parrish, P. (2010). *Transformative learning experience: Aim higher, gain more.* Retrieved from http://carbon.ucdenver.edu/~bwilson/TLE.pdf

Wishart, J. (2009).Use of mobile technology for teacher training. In Mohamed Ally (Ed.), *Mobile Learning: Transforming the Delivery of Education and Training.* Edmonton: AU Press. 267-277.

Wong, S. L., & Hanafi, A. (2007). Gender differences in attitude towards information technology among Malaysian student-teachers: A case study at Universiti Putra Malaysia. *Educational Technology and Society, 10(2),* 158-169

Wozney, L., Venkatesh, V. & Abrami, P. (2006). Implementing computer technologies: Teachers' perception and practices. *Journal of Technology and Teacher Education, 14,* 173-207

Wu, C. F. (2013). Learning attitude and its effect on applying cloud computing service to IT education. *International Journal of U- and E-Service, Science and Technology, 6(1),* 39-48.

Yara, P. O. (2009). Students attitude towards mathematics and academic achievement in some selected secondary schools in southwestern Nigeria. *European Journal of Scientific Research, 36(3), 336*

Zan, R. & Di Martino, P. (2007). Attitude toward mathematics: Overcoming the positive/negative dichotomy. *The Montana Mathematics Enthusiast, Monograph 3, 157-168.*

Zhang, X. H., Xie, F., Wee, H. L., Thumboo, J. & Li, S. (2008). Applying the expectancy-value model to understanding health values. *Value in Health, 11(1),* 61-68

Zimmerman, B. J. (1995). Self-efficacy and educational development. In A. Bandura (Ed.), *Self-efficacy in Changing Societies.* New York: Cambridge University Press. pp 202-231.

APPENDIX A

CLOUD SERVICES IMPACT QUESTIONNAIRE (CSIQ)

Section A: Basic Information

Name of University ……………………………………………………………………

Course Option ☐ B.Sc (Ed) Math ☐ B.Sc.Ed Math/Comp ☐ B.Sc.Ed Math/Stat ☐ B.Sc.Ed Stat/Comp

Sex: Male ☐ Female ☐

Section B: Computer Devices Used in Accessing Cloud Services (Wireless)

Please tick (√) any of the devices you use in accessing Wi-Fi

Computer Device Used ☐ Laptop ☐ Smartphone ☐ Tablet ☐ Palmtop ☐ PDA ☐ Mobile Phone ☐ PC

Section C: Frequency of Use of Cloud Services (Wireless)

Please tick (√) how frequent you use Cloud Services (Wi-Fi)

Usage of Cloud Services (Wireless)

☐ Very Frequent ☐ Frequent ☐ Fairly Frequent ☐ Not Frequent

Section D: Cloud Services Impact on Mathematics Attitude Scale (CSIMAS)

Please indicate the extent cloud services (wireless) affect your attitude towards mathematics in respect of these items (statements).

Please tick (√) as appropriate. VH=Very High, H=High, L=Low, and VL=Very Low.

S/NO	ITEMS	VHI	HI	LI	VLI
	MATHEMATICS CONFIDENCE				
1	I am sure that I can learn mathematics using cloud services.				
2	Mathematics is hard for me even with the use of cloud services.				
3	I find mathematics frightening even with cloud services.				
4	I know I can handle difficulties in mathematics with the aid of cloud services.				
5	It takes me longer time to understand mathematics than the average person even with the aid of cloud services.				
6	I'm not the type to do well in mathematics.				
7	I am proud of my abilities in mathematics when aided with cloud services.				
8	I have a mathematical mind which is enhanced with the aid of cloud services.				
9	I find mathematics confusing even with the aid cloud services.				
10	Most subjects I can handle OK, but I only manage to endure mathematics even with cloud services.				
11	I know I can do well in mathematics by using cloud services.				
12	I know cloud services are important but I don't feel I need to use them to learn mathematics.				
13	I can get good grades in mathematics with the aid of cloud services.				
	AFFECTIVE ENGAGEMENT				
1	I like using cloud services for mathematics.				
2	In using cloud services to study mathematics, you get your answers correct as rewards for your efforts.				
3	Cloud services aid my interest in learning new things in mathematics.				
4	I find many mathematics problems interesting and challenging with the aid of cloud services.				

5	Learning mathematics through cloud services is enjoyable.				
6	I get a sense of satisfaction when I solve mathematics problems with the aid of cloud services.				
7	I feel good about using cloud services to study mathematics.				
8	Mathematics is more interesting when using cloud services.				
9	I have never been excited about mathematics even with cloud services.				
10	I like the idea of exploring mathematical methods using cloud services.				
11	I always look forward to using cloud services to study mathematics.				
	BEHAVIOURAL ENGAGEMENT				
1	If I can't solve a mathematical problem, I use cloud services to try out different ideas on how to solve the problem.				
2	I always try to do assignments with the help of cloud services.				
3	Cloud services make me versatile in mathematics.				
4	When studying mathematics using cloud services, I often think of new ways of solving mathematics problem.				
5	I think using cloud services waste too much time in the learning of mathematics.				
6	When learning mathematics with the aid of cloud services, I try to understand new concepts by relating them to things I already know.				
7	Using cloud services to study mathematics makes it easier for me to do more real life applications.				
8	When I cannot understand something in mathematics, I always use cloud services to search for more information to clarify the problem.				
9	Having cloud services to do routine work makes me more likely to try different methods and approaches.				
10	Using cloud services in mathematics is worth the extra effort.				
11	When I study for a mathematics test using cloud services, I try				

	to work out the most important parts to learn.				
12	I prefer to study mathematics by myself, without using cloud services.				
13	When I study mathematics using cloud services, I try to figure out which concepts I still have not understood properly.				
14	If I have trouble in understanding a mathematics problem, I go over it again using cloud services until I understand it.				
15	When I study mathematics with the aid of cloud services, I start by working out exactly what I need to learn.				
16	I find reviewing previously solved problems using cloud services to be a good way to study mathematics.				

APPENDIX B

VALIDATION REPORTS

APPENDIX C

RELIABILITY ANALYSIS

Mathematics Confidence Sub-Scale

Cronbach's Alpha Coefficient is given as:

$$\propto = \frac{k}{k-1}\left(1 - \frac{1}{S_T^2}\sum_{i=1}^{k} S_i^2\right)$$

Where

k = number of items

S_T^2 = variance associated with the total

S_i^2 = variance associated with each item

$\sum_{i=1}^{k} S_i^2$ = sum of the item level variances

$$\propto = \frac{13}{13-1}\left(1 - \frac{1}{42.4816}\sum_{i=1}^{13} 0.8564 + 0.7476 + 0.9524 + \cdots + 0.8784\right)$$

$$\propto \ = \frac{13}{12}\left(1 - \frac{10.8568}{42.4816}\right)$$

α = 1.08(1-0.26) = 1.08(0.74)

α = 0.80

Affective Engagement Sub-Scale

Cronbach's Alpha Coefficient is given as:

$$\propto = \frac{k}{k-1}\left(1 - \frac{1}{S_T^2}\sum_{i=1}^{k} S_i^2\right)$$

Where

k = number of items

S_T^2 = variance associated with the total

S_i^2 = variance associated with each item

$\sum_{i=1}^{k} S_i^2$ = sum of the item level variances

$$\propto = \frac{11}{11-1}\left(1 - \frac{1}{35.304}\sum_{i=1}^{11} 0.8544 + 0.7076 + 0.84 + \cdots + 0.7456\right)$$

$$\propto = \tfrac{11}{10}\left(1 - \tfrac{8.6012}{35.304}\right)$$

α = 1.1(1-0.2436) = 1.1(0.76)

α = 0.83

Behavioural Engagement Sub-Scale

Cronbach's Alpha Coefficient is given as:

$$\propto = \frac{k}{k-1}\left(1 - \frac{1}{S_T^2}\sum_{i=1}^{k} S_i^2\right)$$

Where

k = number of items

S_T^2 = variance associated with the total

S_i^2 = variance associated with each item

$\sum_{i=1}^{k} S_i^2$ = sum of the item level variances

$$\propto = \frac{16}{16-1}\left(1 - \frac{1}{78.4}\sum_{i=1}^{16} 0.9536 + 0.8944 + 0.9584 + \cdots + 0.8384\right)$$

$$\propto \ = \frac{16}{15}\left(1 - \frac{13.357}{35.304}\right)$$

α = 1.07(1-0.1704) = 1.07(0.83)

α = 0.89

Combined CSMAS (All Sub-Scales Combined)

Cronbach's Alpha Coefficient is given as:

$$\propto = \frac{k}{k-1}\left(1 - \frac{1}{S_T^2}\sum_{i=1}^{k} S_i^2\right)$$

Where

k = number of items

S_T^2 = variance associated with the total

S_i^2 = variance associated with each item

$\sum_{i=1}^{k} S_i^2$ = sum of the item level variances

$$\propto = \frac{40}{40-1}\left(1 - \frac{1}{306.0676}\sum_{i=1}^{40} 0.8564 + 0.7476 + 0.9524 + \cdots + 0.8384\right)$$

$$\propto \; = \frac{40}{39}\left(1 - \frac{32.815}{306.0676}\right)$$

α = 1.03(1-0.107215) = 1.07(0.89)

α = 0.92

APPENDIX D

SAMPLE SIZE DETERMINATION USING TARO-YAMANE'S FORMULA

$$n = \frac{N}{1 + N(\alpha)^2}$$

Where n is the sample size required

N is the population size

α is the level of significance

For this study,

N = 1807

α = 0.05

Therefore,

$$n = \frac{1807}{1 + 1807(0.05)^2}$$

n = 327.5034

n ≈ 328

Hence, the required sample size for the study is 328 mathematics education students.